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Environmental Impact of Land Use on Water Quality. Final Report on the Black Creek Project. Volume 1. Summary

Allen County Soil & Water Conservation District, Fort Wayne, Ind

Prepared for

Environmental Protection Agency, Chicago, Ill

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16. ABSTRACT

This is a final non-technical summary of the Black Creek sediment control project. This project is to determine the environmental impact of land use on water quality, and has completed its four and one half years of watershed activity. The project, which is directed by the Allen County Soil and Water Conservation District, is an attempt to determine the role that agricultural pollutants play in the degradation of water quality in the Maumee River Basin and ultimately in Lake Erie.

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ENVIRONMENTAL IMPACT OF LAND USE ON WATER QUALITY

Final Report
on the
Black Creek Project
(Summary)

by

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Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Photos in the document courtesy Purdue University, USDA Soil Conservation Service, Toledo, Ohio, Blade.

1

NONPOINT SOURCE POLLUTION

A LOOK AT WHAT IT'S ALL ABOUT

Environmental Impact of Land Use on Water Quality

1

The passage of the Water Quality Act Amendments of 1972 — Public Law 92-500 — set in motion the machinery for a re-evaluation of programs designed to control soil erosion in the United States, particularly as these programs relate to water quality standards.

Soil Erosion Near Black Creek

Section 208 of that act mandates the development of water quality management plans which include plans for the control of pollution arising from agricultural operations. Some agricultural pollution, largely that arising from animal waste from confined feeding operations or farm-based agricultural processing plants, readily falls within the concept of "point source" pollution.

On the other hand, pollution which is related to crop production — soil erosion, the introduction of fertilizers and pesticides into the waterways of the nation — is a type of nonpoint pollution and is more difficult to recognize, define, and deal with.

Even before the final passage of PL 92-500, a group of technicians, specialists, and researchers, working under a grant from the U.S. Environmental Protection Agency, were taking a detailed look at how nonpoint source pollution might be controlled in a typical agricultural watershed in Allen County, Indiana.

This volume reports results and conclusions of this study. It provides a general discussion of the project. More information concerning the subject is contained in the three technical volumes which together with this one constitute the final report on "The Black Creek Project."

1

BLACK CREEK & THE PROBLEM OF LAKE ERIE

Dramatic descriptions of environmental pollution — factories spewing forth wastes into the air and water, raw sewage destroying streams and lakes and threatening the viability of the oceans themselves, trash and debris inundating large areas of otherwise useful land — immediately leap to mind when the phrase, "environmental protection" is mentioned.

More subtle and less obvious pollution of the natural environment is easily overlooked. Yet this pollution, designated as nonpoint source pollution, has been identified as equal to or sometimes more serious than pollution entering the environment from large, easily recognized, point sources.

Toledo, Ohio

Since 1972, the Allen County Soil and Water Conservation District, with assistance from the USDA Soil Conservation Service, Purdue University, and the University of Illinois, has been investigating nonpoint source pollution in a 12,000-acre subwatershed of the Maumee Basin under a grant from the U.S. Environmental Protection Agency.

This study, commonly called the Black Creek Study, was the first detailed look in the United States at the contributions of agriculture to the degradation of water quality and ultimately to a reduction of environmental quality.

The Black Creek Study, although now providing information of use to Section 208 planners, actually pre-dates the adoption of Public Law 92-500 which, in part, requires an analysis of the impact of nonpoint source pollution on water quality.

It was funded under provisions of the 1969 Water Quality

Act calling for special demonstration projects to improve the quality of water in the Great Lakes and, in the case of this project, Lake Erie.

If there was a single symbol of the need for environmental protection arising out of the environmental movement of the mid and late 1960's, that symbol was Lake Erie.

President Lyndon Johnson, in his message to Congress urging adoption of the Clean Water Act of 1965, said that for all intents and purposes, Lake Erie was a "dead" lake. Former Environmental Protection Agency Administrator William Ruckelshaus, speaking about an assurance from the City of Cleveland that environmental problems in the Cuyahoga River (a major tributary of the Lake) had been solved said, "The next week the river caught fire and burned down two bridges and a house boat."

Refuse of Cleveland, Detroit, and Toledo poured into the shallow lake; but in addition, pollutants, including nutrients, pesticides, and sediment, were added from the rich farming lands of the Lake Erie Basin.

The 1970 assessment of Lake Erie water quality by the USEPA identified the Maumee River, major drainage artery of a highly agricultural basin, as the largest single contributor of silt to Lake Erie.

It was within this framework that a conference on the Maumee River was held on January 7, 1971. The conference, called by then Indiana Fourth District Congressman J. Edward Roush led directly to the Black Creek project.

Lake Erie at Toledo

The problem, as expressed by an offical of the EPA Region V Enforcement Division was that through existing and contemplated federal programs and individual cooperation,

industrial and municipal pollution of the Maumee River and Lake Erie was coming under control. "When these problems are solved," he said, "the problems of agricultural pollution will remain."

Ellis MacFadden, then chairman of the Allen County Soil and Water Conservation District, paraphrased these remarks this way: "Industry was doing a good job and cities were doing a good job, but agriculture was doing a lousy job."

The spur of the Maumee River Conference led to a series of meetings involving agricultural, environmental, and local state and federal agencies. These meetings, called by Allen County, Indiana Surveyor William Sweet and Thomas Evans, then SCS State Conservationist, considered various alternatives to the problems defined at Roush's conference.

Ideas, ranging from the construction of modified treatment plants to chemically remove sediments and nutrients from water leaving agricultural watersheds, to a system of electrical precipitators designed to cause colloidal-sized particles to drop from flowing streams, were discussed.

Finally, however, it was decided to find out if the traditional methods of attacking soil erosion (which have been applied over the past four decades by the Soil Conservation Service and other agencies of the United States Department of Agriculture) could have an impact on water quality.

Grassed Waterway

The Allen County Soil and Water Conservation District, a subunit of state government funded by local tax funds,

agreed to undertake responsibility for managing the project and making sure that the 25 percent local funding, mandated under the law, was accounted for in the project budget.

The Soil Conservation Service agreed to increase the amount of technical assistance offered to the district under a subcontract funded by the grant. Purdue University researchers, representing agricultural engineering, agronomy, agricultural economics, rural sociology and biological sciences, formed a research team to investigate all aspects of the problem.

Later, a contract with a former Purdue researcher allowed continuation of studies of aquatic ecology through the University of Illinois. These studies have concentrated on near-stream vegetation's affect on water quality, the basic microbiological parameters of the watershed, and the dynamics of fish communities in the Black Creek.

The Black Creek study thus was a demonstration project, supported by detailed research, aimed at understanding the impact of agricultural land use in the Maumee Basin on water quality.

Maumee Basin —Black Creek Location

It was not an attempt to directly have a measurable impact on the water quality in Lake Erie. It is unlikely that any impact on Lake Erie could be detected if all of the water from Black Creek were diverted from the lake. The assumptions have been, however, that a viable method of improving water quality could be developed and demonstrated which would, if repeated in the 200 to 300 similar watersheds of the basin, have a significant effect on water quality in Lake Erie.

NEEDED-NEW ANSWERS TO OLD QUESTIONS

United States Department of Agricultural agencies — Soil Conservation Service, Agriculture Stabilization and Conservation Service, and Extension Service — have been heavily involved in the conservation of soil and water resources for many years.

The efforts of these agencies are focused through Soil and Water Conservation Districts, (local subunits of state government, usually without regulatory powers, but capable of having a major impact on land and water resources).

Traditionally the technical work of the Soil Conservation Service has been aimed at conserving one important resource — soil. Although the conservation and wise use of water has also been an important goal, the reasoning has been that if erosion could be controlled and soil kept on the land, then water quality would benefit.

As more attention has been turned to the problem of nonpoint source pollution, it has become clear that it may be possible to conserve soil within the limits set as necessary for continued production of food and fiber, but nonetheless not meet water quality standards.

If there were two questions of primary interest in the design of the Black Creek project, they were these:

(1) Can traditional soil and water conservation programs have a significant beneficial impact on water quality?

(2) Can programs involving the voluntary cooperation of landowners, encouraged by generous incentive payments, produce land treatment sufficient to improve water quality to the level of present and future water quality standards?

With 40 years of experience in the design and application of land management programs, it might be assumed that the mechanism of erosion control and its relationship to sedimentation would be readily understood. That this is not the case relates largely to the technique that has been used to plan erosion control which is centered around the Universal Soil Loss Equation. This equation (USLE) is based on statistical probabilities and is useful to estimate the probable soil loss from fields. It does not indicate the eventual destination of

sediment, and therefore cannot, by itself, predict the impact on water quality that can be expected from the manipulation of its variables.

The philosophy of the management of land from the standpoint of the Universal Soil Loss Equation has been the

Discussing Conservation Planning

Cropland in Watershed

following: There is a natural regenerative capacity in all soils.

Even if soils are lost through the process of erosion (both wind and water), if the loss can be kept below this regenerative capacity, there is no deterioration of the resource. Reasonably, a program can be developed to bring all soil loss in line with replacement by natural regeneration. This philosophy was developed to maintain the long term productivity of the land and is not directly related to water quality.

Assuming a goal of working toward the degree of treatment necessary for achieving the limits set in the Universal Soil Loss Equation, how can this goal best be achieved?

The traditional approach of USDA agencies has been to use incentive payments, designated as "cost sharing" to encourage the implementation of conservation practices. These payments, administered through the ASCS county committees, have not been limited to practices designed to conserve soil or reduce soil loss. They have also been offered on practices which have as a primary purpose the increasing of soil productivity. These practices often resulted in better income and were the most popular.

Drawbacks to traditional cost sharing programs were considered in the Black Creek project and solutions to them proposed in that:

(1) There was no need to wait for year-to-year appropriation. Cost sharing could be offered at any time during the project when landowners were willing to install needed practices.

(2) There was adequate technical assistance from SCS.

(3) There was aggressive and interested local leadership.

(4) The project enjoyed favorable publicity and encountered no active opposition.

The question then became one of whether a program designed to improve water quality by attacking all agricultural aspects of nonpoint source pollution on a farm-by-farm basis could succeed if it enjoyed these advantages.

Other questions were posed either at the beginning of the project or as work progressed. One of the most important of these had to do with availability of phosphorus to plant life in Lake Erie.

A problem that concerned environmentalists was the frequent occurence of algal blooms and the resulting degradation of water quality caused by the die off and decay of the over abundant algae in Lake Erie. It has been determined in Lake Erie, as in most lakes, that the magnitude of algal bloom is related to the amount of phosphorus available.

1

A five-year project to find out how farming operations affect water quality is drawing to a close in Northeastern Indiana, just as water quality planners are seeking the types of information the project provides.

The project, now generally known as "The Black Creek Project," is being conducted under a $2 million plus grant from the Environmental Protection Agency by the Allen County Soil and Water Conservation District (SWCD). Support is being provided by scientists and Extension specialists from Purdue University, the Soil Conservation Service, and the University of Illinois.

Water quality planners are considering the impact of potential pollution of streams and lakes by agriculture to comply with Section 208 of the Water Quality Act.

Section 208 requires that water quality management plans include methods of controlling pollution which arises from diverse sources, no one of which by itself would be a major water quality problem. Among these diverse sources, called non-point sources, is agriculture.

Ironically, the Black Creek Project and the Water Quality Act were both approved in the same month and year, October 1972. The Black Creek Project was not a direct response to the Water Quality Act, however. (Planning for the project predates the act.) Instead, it is being funded under EPA's special Great Lakes Program, since the ultimate destination of Black Creek's runoff water is Lake Erie via the Maumee River.

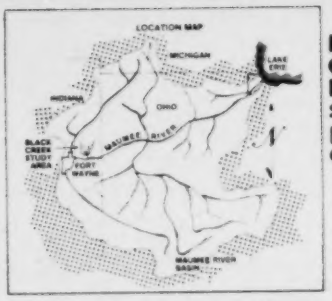
The grant involves research and demonstrations for sediment management treatments, the effects of land treatment in controlling erosion, and monitoring of biological pollutants.

Also included in the Black Creek Project has been research to shed light on the factors which lead some landowners to readily cooperate while others refuse. Projection will also allow an evaluation of how great a reduction in sediment and related pollutants might reasonably be expected from adequately financed and properly conducted voluntary programs.

There are a few months left to go on the project," notes Project

by James B. Morrison
Information Specialist

Is it farming vs. water quality?



Black Creek Project studies pollution, control

Director James Lake. "Although we can't draw conclusions until we publish the final report, there are a few things we can say about Black Creek."

Ellis McFadden, Chairman of the District's Board of Supervisors and newly elected president of the State Association of Soil and Water Conservation Districts said, "There has always been a feeling among Soil and Water Conservation Districts that we could get the job done if there were only enough money available for cost sharing and enough people available in the Soil Conservation Service Office to provide all of the technical assistance needed. This project gave us both people and money."

And did that result in total land treatment in the past four years?

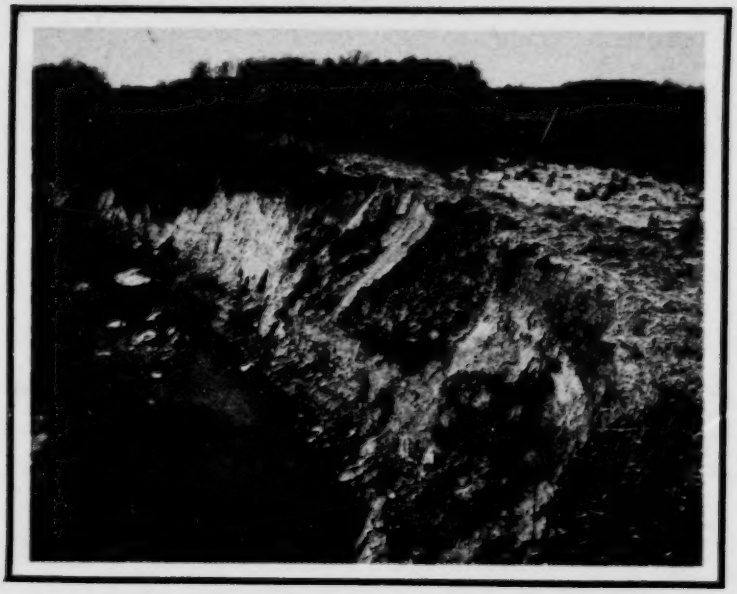
"We are coming to the end of the land treatment part of our program," Lake said. "We think that at this point we have about 57 per cent of the acres in the watershed adequately treated."

Publicity for Project

Algal Pads

It became clear early in the project that most of the phosphorus leaving the agricultural soils of the Black Creek Watershed were attached to soil particles. This provides a tight bond which is not easily broken down when the particles are typical of the colloidal-sized clays of the Maumee Basin. The question became: "How much of this 'sediment bound' phosphorus is available to plant life in Lake Erie or in other receiving bodies of water?"

Also posed were questions regarding bank stability and contributions of ditch banks to the total sediment load of the Black Creek and the Maumee River.



Unstable Ditch Bank

A desire was expressed to be able to attribute the sediment reaching the river and the lake to various classifications of land. It was determined that the soil capability classes used by the SCS would be used and an attempt was made to assign contributions of sediment to each of them.

The impact of land use on the quality of water in Black Creek itself was also a question. This was to be measured by both chemical and microbiological parameters in the stream.

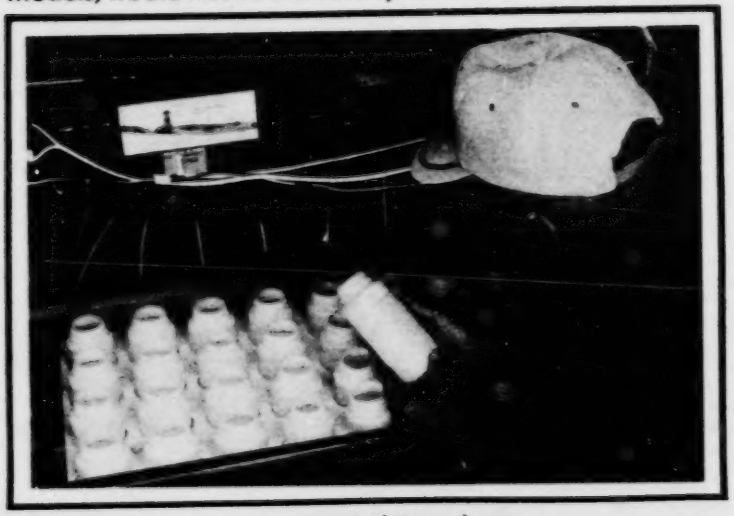
As the project developed, interest was generated in the impact of near- stream vegetation on the water quality of the Black Creek.

As the difficulty of getting consistent measures of water quality and the importance of timing in collecting useful water quality samples became more apparent, it became obvious that an automated sampling system was necessary. A

complex automated system, capable of reacting to storm events and gathering samples when needed during the runoff was developed and installed in the watershed.

Collecting Grab Samples

Finally, some method of applying the results of the Black Creek study beyond the boundaries of the Black Creek Watershed was desired. The vehicle for accomplishing this was to be a computer model. This model, unlike other models, would not be statistically based nor involve lumping



Automated Sampler

of several parameters into numerical values useful only for

characterizing specific watersheds. Instead, an attempt would be made to develop a distributed model, capable of simulating watershed behavior during actual rainfall events.

WHAT DID WE LEARN?

After five years of effort, investigators have been able to draw some tentative conclusions concerning the impact of agricultural land use on the Black Creek environment. Although some of the conclusions raise as many questions as they answer, it is the conviction of the Black Creek staff that the level of understanding has been increased.

One investigator commented that an important thing that was learned from the research standpoint was simply how to conduct this type of study. Changes in direction came about several times. For example, it was learned that grab sampling, the process of periodically dipping out samples of water from the Black Creek and its tributaries was not sufficient to give a true picture of sediment and related pollutant loadings into the Maumee River.

Tillage Demonstration Plot

As a result, automated samplers were installed at several testing locations. Information from these samplers are thought to give a more accurate measure of concentrations throughout the period following a rainfall event in the watershed. The information thus makes possible a more accurate assessment of the impact of land use on water quality.

The concept of tillage trials was changed, from a system in which individual farmers utilized techniques to be tested, to the more traditional tillage research methods using replicated plots. Farmers naturally tended to be more

concerned with regular field operations rather than research.

The need to measure microbiological parameters was established after the project had begun. This work was added and performed by the Ft. Wayne-Allen County Board of Health. A study of near stream vegetation on water quality was begun after the project had started. Both of these projects supplemented the study of fish community dynamics in the Black Creek.

A summary of conclusions reached can be divided into two major categories — a summary of the research and a summary of those things learned which were associated with the administrative aspects of the watershed and the impact of an accelerated land treatment program on the people of the Black Creek area.

Research Conclusions

Research results in the Black Creek Watershed indicated nitrate loadings were typical of agricultural watersheds (2-20 kg of nitrate nitrogen per hectare) and not high enough to threaten drinking water standards (10 mg/l); phosphate concentrations were high enough (.05-.16 mg/l) to threaten water quality goals for Lake Erie (.01 mg/l); and sediment was being produced after rainfall events which produced runoff, with most sediment (73-86 percent) produced by intense

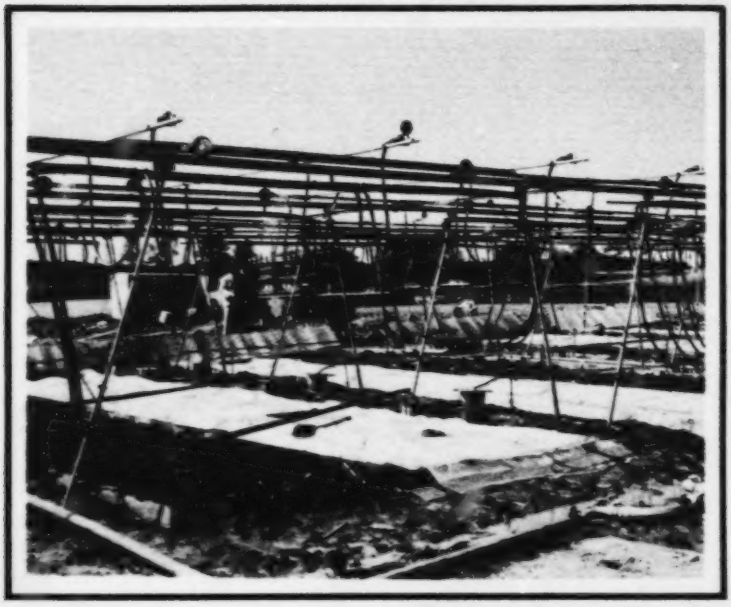
Sediment Runoff On Roadway

storms. In general, sediment loadings into the Black Creek were low for an agricultural watershed, but more typical of the Maumee Basin. These ranged from 530 to 2370 kg/ha

(from a little more than a quarter to slightly more than a ton per acre per year). These loadings were measured at the discharge point into The Maumee River. It should be noted that loadings of this magnitude would have been undetectable if measured in the river itself downstream of the discharge point. More particularly, changes in loadings in this range could not have been measured in the Maumee.

Of all the water quality parameters measured, most could be correlated with sediment. The single exception was nitrogen, particularly in its nitrate form, which was leached from the soil and was present in surface water, subsurface drainage water, and tile flow. Amounts of most of the pollutants considered could be reduced by controlling sediment. This is not the case with nitrogen.

Methods of controlling nitrogen include utilizing techniques which slow the rate of nitrification, paying particular attention to the time of application, and reducing



Rainfall Simulator in Operation

the amount of nitrogen applied as fertilizer. Nitrate levels detected in the Black Creek do not justify other more excessive control measures on the basis of either health or currently perceived nutrient problems.

Phosphate levels were high enough to be of concern, particularly if continuing studies demonstrate that sediment-bound phosphorus is an important source of the nutrients for algal blooms in Lake Erie. There is reason to believe that a significant level of reduction of phosphates can be achieved

through controlling sediment.

Simulated rainfall tests have demonstrated that raindrop impact is of prime importance in the detachment of soil particles. Farming techniques which maximize surface residue, thereby providing soil cover and consequent protection from raindrop impact are very important in preventing erosion from occurring. Other practices, chiefly of a structural nature, such as establishment of vegetative borders around farm fields, construction of systems of terraces to shorten slopes and hold runoff water for short periods of time to allow sediment to settle out, and the construction of sediment basins in drainageways may have value in removing sediment from water containing soil that has been detached.

Still other structural practices, such as grassed waterways, structures to stabilize soil at abrupt changes in elevation, establishment of vegetation or other techniques in extremely unstable areas, have primary value in preventing erosion induced by runoff of surface water.

Wertz Woods

It was established that a very small percentage of the sediment entering the Maumee River and Lake Erie can be attributed to unstable ditch banks or channel banks. Standard techniques of reconstructing channels to speed away drainage water are questioned from the water quality standpoint. These methods retain value from the standpoint of farm drainage.

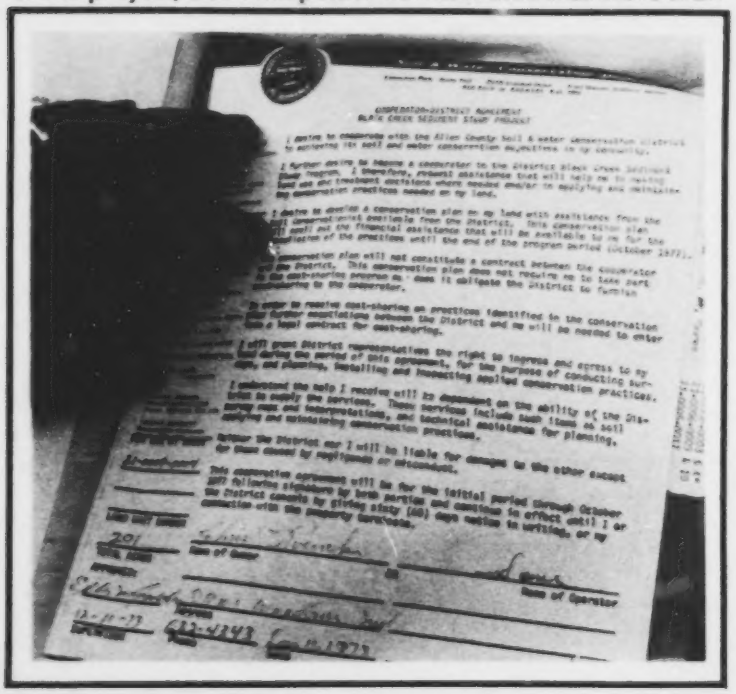
Tests in a small woods, the Wertz woods, indicated that during base flow, sediment may be deposited in the meandering stream bed through the woods. In addition, the importance of tributaries like the Black Creek in maintaining the fishery of the Maumee River was established. Disturbance of streams and ditches through reconstruction interferes with breeding of several species.

Finally, a computer model of sediment production and transport, called ANSWERS, has been developed which appears to be very useful in locating areas within small watersheds which have a proportionally greater impact on water quality. The model should be useful for water quality management planners who need to identify areas where control of erosion is most critical to success of the plan.

From the standpoint of public acceptance, the Black Creek project has been a success. Cooperation has existed from the Federal level, through state government and to local units of government. Support has come from public interest groups representing various positions.

Administrative Aspects

Landowners have accepted the project: 95 per cent are cooperators. At the conclusion of the land treatment portion of the project, SCS field personnel estimated that more than



Cooperative Agreement

80 per cent of the land area in Black Creek was adequately protected from soil loss which would threaten the continued usefulness of the land resource. This projection has not been related directly to water quality.

Costs of achieving land treatment have been relatively high, leading Black Creek investigators to the conclusion that an accelerated program of land treatment on a large scale would likely be too expensive. When the Black Creek cost ($75 per acre including district payments, landowner contributions, and technical assistance) is applied to the entire Maumee Basin, the total is staggering. However, both the economic and ANSWERS models developed in the project hold out hope that significant water quality improvement can be obtained by concentrating treatment on selected critical areas rather than attempting immediately to treat every acre of land. It is likely that many acres in the Maumee Basin will in fact require no treatment.

It has been concluded that early efforts at conservation planning in the Black Creek Watershed were too broadly based and that individual conservation plans were too complex to be readily understood or administered.

The list of 32 practices to be tested in the Black Creek Watershed was reduced to 12 practices considered best management practices from the water quality standpoint. If efforts had been concentrated on these practices, it is likely that a higher degree of participation would have been produced on the project and that landowners would have better understood the thrust of the program.

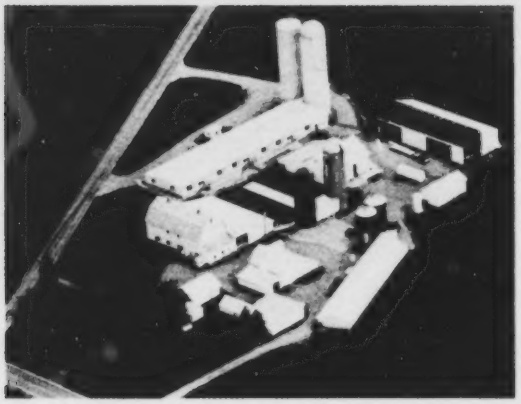
Black Creek At Maumee River

An economic model was developed to analyze the cost of nonpoint source pollution control on farms in the Black

Creek Watershed.

This model demonstrates that the cost of achieving reduction in sediment through change of tillage methods is dependent on two major recurring factors — crop yield reductions that could be associated with alternate tillage methods and the market value of farm crops. Previous tillage studies have identified those areas which could most benefit from change in tillage to control erosion as the same areas which are least likely to suffer significant yield reductions because of changes in tillage. This emphasizes the need for planners to be selective in dealing with recommended tillage changes as a means of achieving nonpoint source pollution control.

The Black Creek project has demonstrated the ability of the Allen County Soil and Water Conservation District to efficiently deal with an extensive program of nonpoint source pollution control, to handle fairly large amounts of money, and to deal with landowners on a voluntary basis. This success should make soil and water conservation districts in general likely vehicles for undertaking this type of work as Section 208 plans are put in place.



2

WHY CHOOSE BLACK CREEK?

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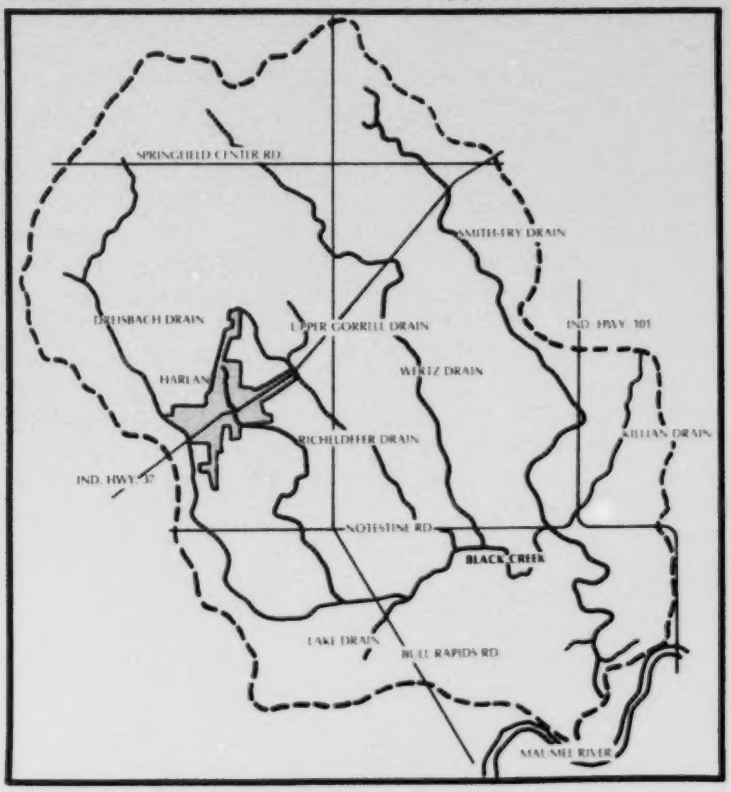
The selection of a watershed for the study was made following a six month planning phase. Selection of a study area was considered critical to the application of results to



Black Creek Watershed

other parts of the Maumee Basin. A set of criteria was adopted to facilitate the conduct of the study and to make the results as broadly applicable as possible.

The criteria, identified early in the project, were as follows:

1. The study area should include lake bed and upland soils which are reasonably representative of much of the total Basin.

2. Sufficient drainageways should be present so that monitoring stations could be installed to evaluate erosion and sedimentation both from upland areas and from where the channel enters the Maumee River.

3. Present land uses and cultural practices should be comparable to those of the total Maumee Basin.

4. Anticipated future land uses should be typical of those expected throughout the Maumee Basin.

5. The physiography of the study area should facilitate the separation of runoff between agricultural areas and land under other uses.

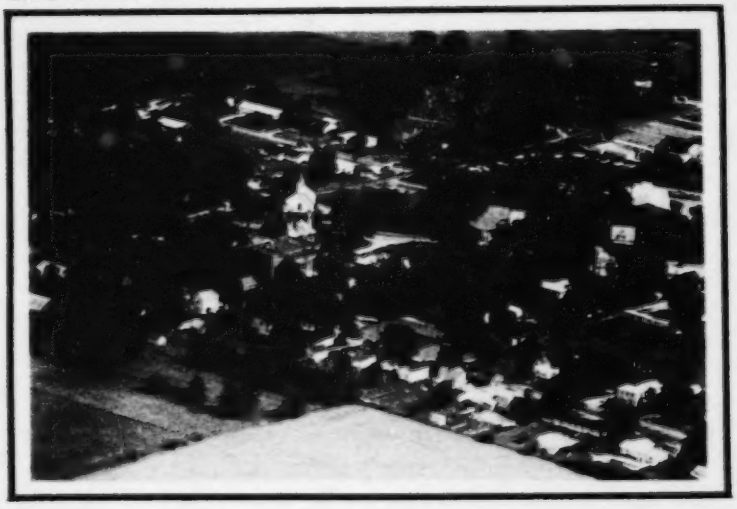
6. It is desirable to have "court" (legally established as drainage ditches under Indiana law) ditches in the area with long time records.

7. The study area should drain directly into the Maumee River.

8. The area should be no greater than 20,000 acres in size.

The Black Creek area, made up of 12,038 acres in northeastern Allen County, Indiana, was selected as the area within the jurisdiction of the Allen County Soil and Water Conservation District which most nearly satisfied all of these criteria. The area contains both soils and land uses which are representative of the basin. Great similarities of land use between the Basin and the Black Creek study exist. About 73 per cent of the basin's 4,229,100 acres is devoted to cropland. Slightly more, about 80 per cent, of the study area is cropland. Pasture land makes up 4 per cent of the Maumee Basin and a little more than 4 per cent of the study area. Woodland is higher in the Maumee Basin as a whole, representing about 8 per cent of the land area. Woodland represents about 4 per cent of the Black Creek area. Urban buildup of the Basin, represented by the major population centers of Fort Wayne, Ind. and Toledo and Lima, Ohio, represents about 9 per cent of the Basin and only about 4 per cent of the study area.

However, if the population centers are neglected, the major urbanized area of the Black Creek, the town of Harlan, is typical of the small towns and villages which are scattered all over the basin.



Town of Harlan

Corn and soybeans are the major crops produced in both the basin and the study area. Small grains and meadow in

rotation represents a correspondingly smaller amount of the cropland.

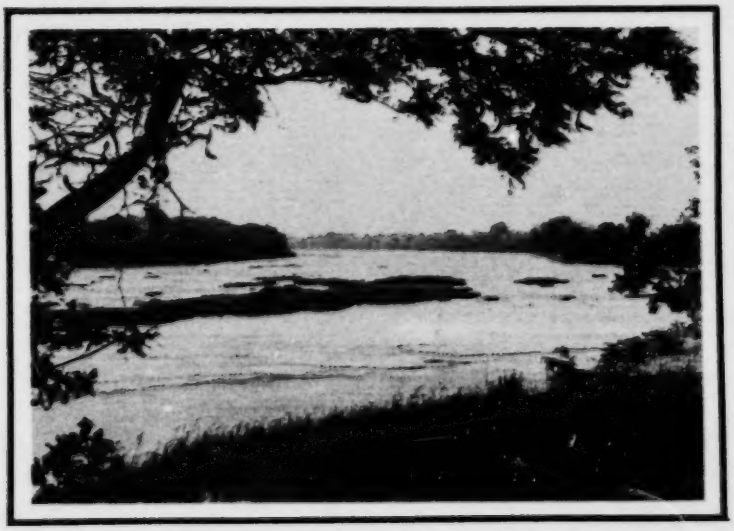
Only two soil types — Paulding and Latty — which are found in the north part of the lake plain east of Archbold and Van Wert, Ohio, are not represented in the Black Creek Watershed. These soil types are being considered in a separate study conducted by Ohio State University.

In general, the characteristics of Black Creek were excellent for representation of the Maumee Basin. It was intended that results of studies of the Black Creek would therefore be applicable to large areas of the basin. Consequently, work would be representative of the impact that could be achieved in a program aimed at treating sources of nonpoint pollution in this major Lake Erie subbasin.

THE MAUMEE BASIN ON A SMALLER SCALE

The Maumee Basin, representing a relatively new geological area, is rich in history. The basin includes 6,608 square miles, most of which are in northwestern Ohio, but about a fifth of which are in northeastern Indiana. There are about 4.2 million acres in the basin, including all or part of 26 counties: 17 in Ohio, 6 in Indiana and 3 in Southern Michigan.

The Maumee Basin was one of the last areas of the Lake Erie Basin to be settled, although outposts at Fort Wayne and Toledo were established before 1800. Names of communities in the basin, such as Fort Recovery, and Fort Defiance, are



Maumee River at Waterville, O.

evocative of the early history of the region which was marked by a struggle between the fledging Government of the United States and a confederacy of tribes of the Miami Indian Nation for control of the Old Northwest Territory.

A decisive battle in this struggle occurred just west of Toledo along the Maumee River. This was the Battle of "Fallen Timbers" where American Army Regulars and volunteers from Kentucky and more settled parts of Indiana defeated Miamis under the leadership of Chief Little Turtle. General "Mad" Anthony Wayne, the third and only successful leader of expeditionary forces against the Miamis, directed the battle which made possible the opening of the area to settlement and eventually to intensive agriculture.

In fact, a limited agriculture was practiced in the Maumee Basin by Miami Indians who burned vegetation from well drained areas in the basin and even in the "Great Black Swamp" to clear the land for corn culture.

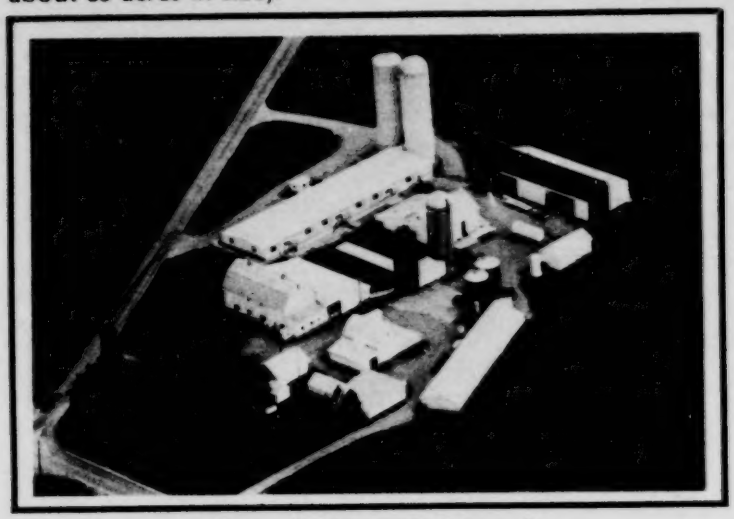
The "Great Black Swamp', comprising the area which was once occupied by former glacial Lake Maumee, provided a barrier to land transportation and to development of agriculture in most of the Maumee Basin. Although the area today is the most productive and largest single agricultural region in the entire Lake Erie basin, it was historically important as a transportation linkage. The Maumee River allowed the connection of the Great Lakes. — St. Lawrence River canoe routes of the early 17th Century with the Wabash-Ohio-Mississippi waterways through only a single portage of about eight miles at Fort Wayne. The Maumee was thus early described as the "Glorious Gate" from the Northeast to the West.

It was primarily German settlers, with their knowledge of farm drainage, who brought the rich, black soils of the former lake bed into productive use. By the middle of the 19th century, the dense forests of the basin had been cleared and large areas of the swamp had been drained through elaborate systems of both surface and tile drainage. The farm drainage system of the former bed of old Lake Maumee is very complex and elaborate, requiring regular maintenance and periodic reconstruction to allow it to function.

The Black Creek Watershed is largely a rural area. It has, however, two effectively different populations. Uplands of the watershed include a large Amish population. The Amish, for religious reasons, eschew many types of machinery, electricity, and other modern conveniences. They therefore represent a type of agriculture typical of the farming methods of three-quarters of a century ago.

For purposes of classification, farms in Black Creek can be broken down into the following five categories. Full time

large non-Amish (averaging about 680 acres), full-time medium non-Amish (averaging about 250 acres), part time non-Amish (averaging about 61 acres), full-time Amish (averaging about 120 acres) and part time Amish (averaging about 85 acres in size).



Watershed Area Farmstead

In addition to the use of horses as a major power source and the tendency to utilize more human labor per farm, Amish farmers use less commercial fertilizer than do non-Amish farmers, have lower average yields, and have more land in pasture. Their farming techniques are less adapted to certain erosion control techniques such as conservation tillage and are more susceptible to stream bank problems caused by the use of the streams to water animals. In general, Amish farms have proportionally more animal waste and consequently have a greater animal waste disposal problem.

A GUIDE FOR 208 PLANNERS

In a very real sense, the Black Creek Watershed represents an area in which easily identified major soil erosion problems did not exist. There were few developing gullies or other dramatic, easily identified examples. Lack of protection of stream banks, eroding channels, erosion at abrupt changes of elevation, and related problems could be found, but were easy to overlook.

Monitoring has revealed sufficient soil loss and nutrient loss in the Black Creek Watershed to indicate that visible evidence of serious erosion on the land is not required for water quality to be degraded. This emphasizes the difficulty of dealing with the problem of agricultural nonpoint source pollution.

2

One way of considering Black Creek Watershed in relationship to watersheds with more serious and more easily apparent erosion problems, is to consider that Black Creek represents a watershed as it might be after the major attempts at erosion control have been completed. The forming gullies have been checked; areas of new channel cutting have been stabilized; and the erosion and related problems which remain come primarily in the form of insidious soil loss spread over large areas of land. Unfortunately, these problems that do remain are both the most difficult to understand and the hardest to solve.

Information in the series of reports that constitute the Black Creek Watershed final report, must be interpreted and applied with care. Some of the information presented is of general use, some may be applicable in the Maumee Basin only, and some is applicable only to the Black Creek Watershed itself.

There are definitely ways in which the information should not be applied. It would be wrong to utilize conclusions of the Black Creek report as a "shopping list" for selecting 'best management practices" that could be used in any watershed. The development of a concept for selecting best management practices, and the approach to designing a program of utilizing a well defined list of practices is well suited to planning in almost any area.

Cost data should particularly be approached with caution. The cost of applying land treatment in the Black Creek Watershed has been high. It would be possible to view these data as unrealistic (because of the amount of cost sharing that was available) and it is readily conceded that some money was spent on projects or plans that have later been determined to have little direct impact on water quality. Some treatment was undertaken which was undoubtedly unnecessary. However, the cost of installing individual practices on a per unit basis (such as the per-acre cost of installing grassed waterways) has not been higher in Black Creek than it is in Indiana generally.

A disproportionate amount of money may have been spent on stream bank protection and channel stabilization, particularly since it is now believed that a very small percentage of the soil loss in the basin comes from stream and channel banks. Conversely it has become clear that the relationship between dollars spent and amount of erosion control achieved or improvement in water quality obtained, while not precisely defined, is definately not a linear relationship. It simply requires more money to eliminate some forms of nonpoint source pollution than it requires to eliminate other forms of nonpoint pollution.

For the Maumee Basin, a simple multiplication of the cost per acre of treating the Black Creek Watershed, by the number of acres of cropland in the total Basin, probably represents the upper limit of the amount that might need to be spent for treatment of every acre of land in the basin. It represents a conservative estimate of the amount that would probably be required to adequately treat areas which included more large, easily identified single sources of erosion. The development of the "ANSWERS" model in the Black Creek Area clearly indicates that it may not be necessary to attempt to treat every acre of land in every watershed to achieve a satisfactory impact on water quality.

Armor Plating

The application of the ANSWERS model is not limited to either the Black Creek Watershed or to the Maumee Basin. It can be adapted to other agricultural watersheds with the provision that data files specific to the watershed in question be provided.

Information necessary to adapt the model to other watersheds is available from soil surveys, geological survey quadrangle maps, and can be obtained from visual inspection or from aerial investigation.

In this sense, the Black Creek Watershed can be considered a test case for the development of a model of general applicability.

3

AGRICULTURAL POLLUTION

WHAT IS IT?

3

Agricultural water pollution is the intentional or accidental degradation, as the result of agriculture, of water quality in any natural stream or body of water.

Administratively, water pollution sources have been divided into point and nonpoint categories with point sources being defined as locations at which relatively large amounts of pollutants arising from single, easily identifiable sources are discharged into waterways. Nonpoint sources are defined as sources which collectively can cause significant degradation of water quality. They are difficult to recognize, identify or control.

Within agriculture, both point and nonpoint sources can be theoretically identified, although agriculture is usually considered in the nonpoint category. For example, large livestock feeding operations can produce point source pollution. Effluent from agricultural processing operations, even if the operation is located on and conducted as a part of a farming operation, can be a point source of pollution.

From the standpoint of enforcement, it is possible to consider a point source as a pollution source, abatement of which will achieve a significant reduction of pollutants and abatement of which can be achieved through the action of a limited number of individuals or corporate owners. Conversely, enforcement actions directed against a single entity in a nonpoint source pollution complex would not be likely to produce significant pollution abatement.

It is usually easier to identify a management technique which will be effective in eliminating point sources of pollution. Pollution from nonpoint sources can be reduced through management techniques, but the definition of these techniques is more difficult and their success less easy to predict.

From the standpoint of weather, a point source is almost invariably independent of weather. A nonpoint source is almost invariably weather dependent.

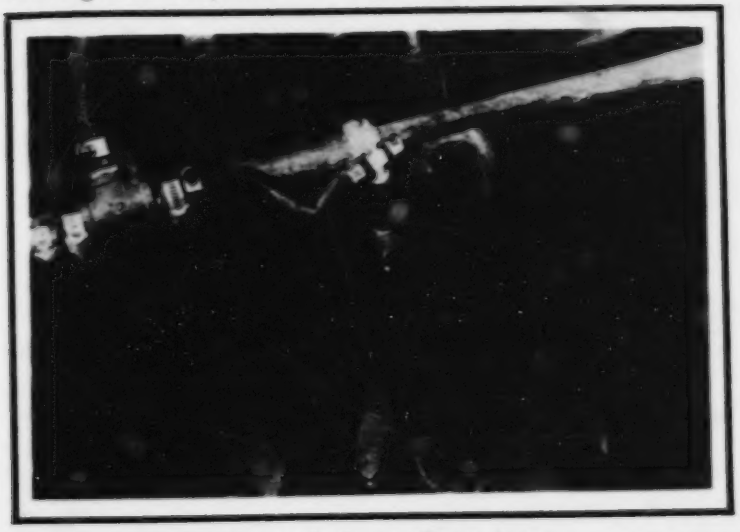
The ability to specify a management technique that would eliminate a certain type of either point or nonpoint source pollution, does not necessarily mean that it is feasible to apply that technique.

For example, the effluent of septic tanks which drain directly into drainage ways, can be considered either a point source or a nonpoint source of pollution. Septic tank pollution can be theoretically eliminated by the installation of a sewage collection and treatment system which would allow the effluent of each septic tank to be collected for necessary treatment in a central plant. The existence of this potential solution does not mean that is economically feasible to apply it.

Animal waste can be either a point source or a nonpoint source of pollution. If the source of pollution is large, involving the discharge of some effluent to a stream, it is a point source. Runoff from manure spread near streams on frozen ground constitutes a typical nonpoint source.

Feedlot Located on Streambank

If pesticide residues are finding their way into drainage ways in unacceptable levels despite proper application and use, the problem is a nonpoint problem. If pesticides are finding their way into drainage ways because users have



Pesticide Spray Apparatus

decided that dumping is the most convenient way to dispose of unused pesticides, the source is a point source.

In the Black Creek Watershed, and in most agricultural areas, the method of dealing with agricultural point sources of pollution are relatively straight forward. A mechanism for dealing with misuse of pesticides is being put into place. Point sources relating to animal waste management can be controlled through regulation, and it is well within the currently available technology to construct disposal systems for animal waste which are relatively pollution free.

Much less clearly defined are the methods of control of the major nonpoint source pollutants typical of agricultural watersheds and the Black Creek — sediment, plant nutrients, and agricultural chemicals which, although properly used, nonetheless find their way into lakes and streams. A discussion of each of these follows:

SEDIMENT

Soil particles detached by soil erosion which find their way into bodies of water become sediment. Sediment is defined as a pollutant. By weight it is the largest single pollutant. It is less obvious than some other materials, which degrade water quality.

If sediment concentrations are allowed to become high enough, aquatic life can be affected. High sediment concentrations have particular impact on certain invertebrate stream life such as crayfish. Higher concentrations can result in the clogging of gills of fishes, and can interfere with spawning or breeding.

Sediment is also a nuisance if deposited in navigation channels. It can choke drainage ways, reducing the amount of storm water which can be carried away from watersheds.

Because high sediment concentrations reduce light penetration of water, certain stream and lake biological systems can be impaired. Rooted aquatic plants are often damaged.

Maumee Basin and Black Creek sediments have a high proportion of clay-sized material. These small clay particles are particularly difficult to settle out of moving water, resulting in a turbid appearance of the Maumee River, even during periods of low flow when the amount of sediment carried is relatively small.

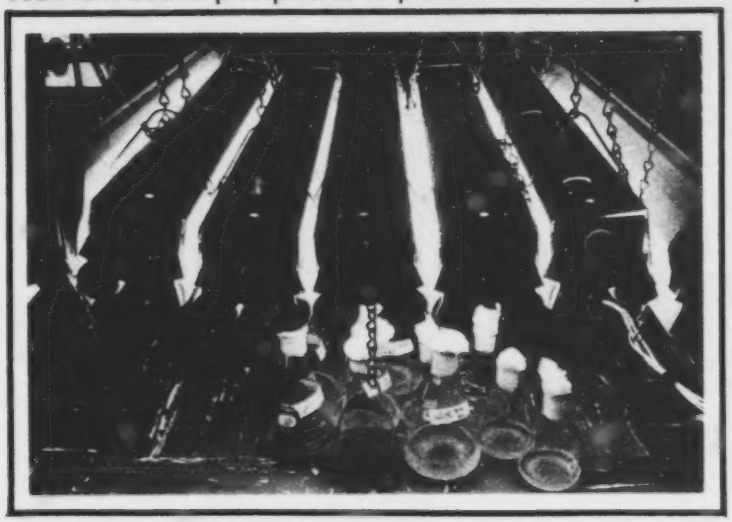
A major impact of sediment as a pollutant does not relate to the soil particles themselves but the ability of soil particles to serve as a vehicle carrying other pollutants into the stream. High clay soils such as those in the Black Creek Watershed are particularly suited to this purpose.

3

PLANT NUTRIENTS

The important plant nutrients carried from the Black Creek Watershed into the Maumee River are nitrogen and phosphorus. A relatively small amount of each of these classes of nutrient is carried into the Black Creek after having been dissolved in either surface or subsurface runoff water. Larger amounts of phosphorus are attached to soil particles and are carried into the water when the particles themselves are detached and moved from the watershed.

From 90 to 96 per cent of the phosphorus transported during one monitoring year in the watershed were associated with sediment. Studies of the availability of this sediment bound phosphorus to plant life are incomplete.



Algal Laboratory Equipment

Nitrate nitrogen concentrations are typical of those found in other agricultural watersheds. They are generally higher than those found in the Maumee River, but do not exceed established drinking water standards of 10 mg/l.

The findings concerning agricultural nutrients lead to two tentative conclusions. Total phosphorus can be reduced to a large extent by controlling erosion. Nitrates could be reduced by timing application of fertilizer closely, use of a nitrification inhibitor with fertilizer or, in extreme cases, limiting application.

Phosphate concentrations in Black Creek are not significantly different than those in the Maumee River. A large fraction of the soluble inorganic phosphorus appears to be entering from septic tanks. This percentage (estimated at 50-70 per cent) is more associated with urban development than agriculture since the number of farm houses is relatively small.

3

OTHER ENVIRONMENTAL HAZARDS

Pesticides, like agricultural nutrients, can be carried into streams along with detached soil particles.

Herbicides for Reduced Tillage

Although the introduction of sediments and agricultural chemicals into drainage water is one of the most significant impacts of agricultural land use on water quality, there are other impacts which have been identified in the Black Creek Watershed.

Channel work and the removal of near-stream vegetation has an impact on both aquatic life and on the amount of soluble nutrients that are present in the drainage water.

Fish studies have indicated an importance for small tributaries of the Maumee River in maintaining the river fishery. Mature fish move into Black Creek, subsequently spawn, and fry remain in the tributary for a significant period of time before returning to the Maumee River. These are the key steps in the breeding behavior of several species of game, forage and rough fish.

Alteration of channel configurations, channel blockage through erosion control structures, destruction of habitat diversity in the channel, or the introduction of stone plating and other bank stabilization methods in a tributary, effectively prevents the use of that tributary for fish breeding purposes for a significant period of time.

Reconstruction of all tributary channels in a lengthy stretch of the river could close that stretch of the river to fish breeding with an adverse effect on the total Maumee fishery.

Removal of near-stream vegetation also has the effect of increasing water temperature, making the aquatic environ-

ment hospitable to a narrower range of species. In addition, laboratory experiments have confirmed that more phosphate is shifted into the soluble phase when water temperatures increase above about 75 degrees F, a level that is typical of slowly flowing, unshaded, shallow drainage ways in an agricultural watershed.

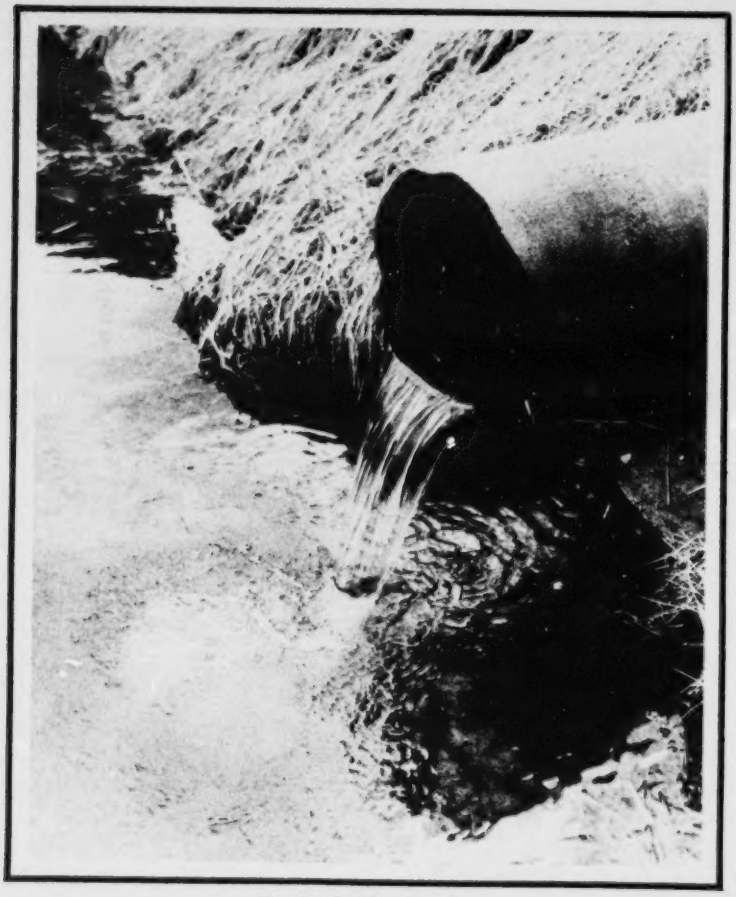
Collection of Fish Samples

WHERE DOES AGRICULTURAL POLLUTION COME FROM?

Any meaningful program to control agricultural pollution has to make an attempt to define the sources of this pollution. Some prime candidates for the sources of pollution are eroding ditch banks, gross soil erosion, surface runoff water, natural subsurface drainage, and tile flow.

Much attention has been given to erosion from unstable ditch banks. An early question in the Black Creek Watershed concerned the percentage of the total Maumee sediment load that could be attributed to ditch banks. Studies conducted by SCS for the International Joint Commission on Water Quality, put this percentage quite low. Current estimates are that about 3-5 per cent of total sediment can be attributed to ditch banks. One researcher commented that if you assume that all of the material removed to construct

open ditches had been transported as sediment over the history of the ditch, the amount of material would still represent a very low portion of the total yearly sediment load in the Maumee River.



Typical Tile Outlet

Traditional methods of controlling erosion from ditch banks — rip-rapping, channel reconstruction, seeding, vegetative covers, — are unlikely therefore, to eliminate a significant portion of the total sediment. Much attention has been paid in the Black Creek project to channel stabilization projects.

Although removing all of the erosion related to ditch banks in Black Creek watershed could not reduce total loadings by more than a few percent, the practice is both visible and popular with landowners because of drainage benefits which follow channel improvement. Project administrators believe that many other conservation practices would have been difficult to achieve if channel work had not been completed.

When a voluntary program is being undertaken, requiring local cooperation and public acceptance, work on stabilizing ditch banks and reducing their erosiveness is important to success.

Rip-rapping

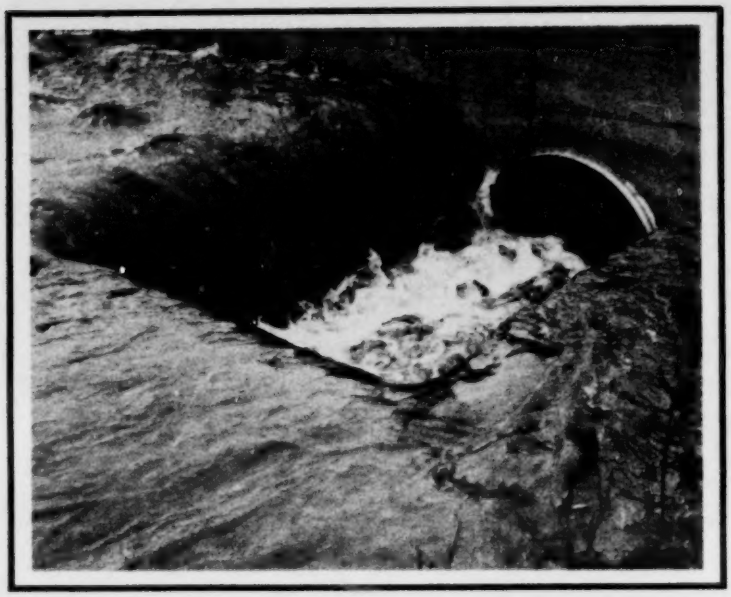
Surface Flow

Water which enters a watershed must leave as overland flow (designated here as surface flow), tile flow, natural subsurface drainage, evaporation, plant transpiration, or by mechanical withdrawal. Water which does not leave either remains in ponds or recharges ground water and soil moisture supplies.

Runoff water can be divided into the categories of tile flow, subsurface flow, or surface runoff.

In the Black Creek Watershed, an attempt was made to separate the types of flow and determine which pollutants were most associated with which types of flow. Although about 50-65 per cent of the runoff identified was attributed to surface runoff, more than 95 per cent of the sediment was attributed to this type of runoff. More water left as surface runoff during periods of high rainfall. Nutrients associated with sediment (sediment bound phosphorus and sediment bound nitrogen) also had more than 90 per cent of their total

attributed to surface flow. High percentages of most soluble nutrients were also attributed to surface flow. Only nitrogen in its nitrate form was more concentrated in other types of flow.



Surface Flow

This leads to an obvious conclusion that sediment, and sediment related nutrients, can be controlled by either preventing them from entering surface runoff water or by removing them from surface runoff water before the water is allowed to enter the receiving stream. Vegetation, is an important key to either of these practices.

Vegetative control of surface flow can be considered in terms of grassed waterways, grass filter strips along stream and ditch banks, and in terms of crop residue management through some form of conservation tillage to leave the soil surface covered for as much of the year as is possible.

Studies with simulated rainfall have confirmed the importance of raindrop impact in detaching soil particles for transport as sediment. For reasons to be discussed later, conservation tillage and crop residue management must be ranked as very important management practices for improving water quality. Their economic feasibility in all farming situations remains less certain.

Key to the Process — The Rain Drop

The importance of the raindrop in detaching soil particles which could become a part of the sediment load carried by surface flow were underscored in simulated rainfall tests

conducted in the Black Creek Watershed. On all of the soils tested, raindrop induced runoff contained approximately 10 times the sediment concentration of that obtained when runoff was introduced by allowing water to flow over the surface onto the test plot. These results suggest the importance of protecting the soil surface from raindrop impact if sediment concentrations in runoff are to be minimized.

Surface cover can be produced either by living plants during the late spring and summer months or by crop residue during the late fall, winter, and early spring. Of the major crops in the watershed — corn and soybeans -- corn will produce more surface cover if identical tillage methods are used.

Chisel Plow Preparation

Corn residue left undisturbed, can cover 70-80 per cent of the soil surface, during the critical period of winter and early spring while soybean residue may cover only about 25 per cent of the soil surface when no tillage has been undertaken.

It might be expected that similar soils and identical tillage methods would produce greater erosion following soybeans than following corn in the Black Creek area. This has proved to be true.

That portion of sediment and related pollutants carried in surface runoff that can be eliminated by maintaining surface cover is dependent on the crop. It is also dependent on the type of tillage that is applied. From the standpoint of erosion control, methods which leave the greatest amount of residue on the surface until the new crop has been established would have to be given a high priority.

In general, a system which involved no tillage of the soil

would be expected to have the greatest positive impact on water quality while a system which involved removal of most of the surface residue, such as fall moldboard plowing, would have the greatest negative impact on water quality. As a note of caution, it should be pointed out that economic and management considerations are a factor which is not included in the water quality evaluation.

In the old bed of Lake Maumee, fall plowing of cropland is a standard farm management practice. Some of the reasons for this relate to general farm management recommendations. Others are uniquely determined because of the characteristics of the poorly drained, heavy soils of the basin.

Corn Planted After Cover Crop

Farm management specialists generally recommend fall plowing as a means of spreading labor and equipment usage throughout more of the year. Fall plowing also helps prepare the soil so that timely planting is more likely in the spring, even under adverse weather conditions. The weathering of unprotected soils in the basin is considered an important soil conditioner, helping to break up clods, soften the hard clay soils, and in general to produce a soil condition that is much more suited to seed germination. In general crop specialists have demonstrated that the yield penalties from late plantings are more severe than those associated with early plantings, even when an unexpected frost intervenes.

In the Maumee Basin, if moldboard plowing with several secondary tillage operations is to be utilized, and the work is left until spring, the chances of being able to achieve timely

planting are very small, particularly in a wet spring.

Simulated rainfall tests show soil losses on Black Creek soils ranging from less than 100 pounds per acre on nearly level land to about 2.5 tons per acre on rolling uplands for which no tillage was performed. Losses of nearly 12 tons per acre were noted on fall plowed rolling land in the uplands.

These tests were made to simulate late winter and spring rainfall. Application was five inches of simulated rainfall, applied in two storms and one day apart.

The reduction in soil loss which can be achieved by adopting no-till planting is less following soybeans than following corn. Even following soybeans,however, losses from fall moldboard plowing are significantly greater than losses when no tillage is performed. In general, losses following corn were only about 12 per cent of the loss following soybeans when no tillage was applied and were 68 per cent of the loss following soybeans when fall plowing was the practice.

These tests were made at only one stage of the erosion season, although at a critical stage.

Factors which must be considered before recommending alterations of tillage are considered later in this discussion.

The fact that remains is that preventing sediment from becoming part of surface runoff is largely dependent on providing adequate surface cover.

Removing Sediment from Surface Runoff

Methods have been proposed to remove detached soil particles from runoff before the water enters the streams. These methods can be divided into vegetative and non-vegetative methods. Primary vegetative methods that have been discussed involve grassed waterways and grass filter strips.

Grassed waterways are primarily designed to prevent the formation of gullies at areas in which significant volumes of drainage water run over land surfaces. Success of this practice in accomplishing this goal has been documented. If grassed waterways are designed with grass varieties and physical construction so that large amounts of sediment drop out in the waterway, the success of the waterway in removing sediment quickly leads to its failure. The waterway becomes filled with silt, vegetation is destroyed, and the water seeks another course to its eventual destination. During storms which produce small amounts of runoff, waterways may have some filtering capacity. Also, they may remove some fraction of sediment and nutrients during larger events. This fraction is small, however. Waterways primarily protect from surface scouring while transporting drainage water.

Grass filter strips, on the otherhand, may have a certain utility. Tests with the rainulator determined that a 50-foot strip of bluegrass sod removed as much as 46 per cent of the sediment carried in water flowing from the test plot. Unless the filter strip is intended to remove all of the sediment from a rather limited surface drain inlet to the drainage stream,

Field Border

PTO Terrace

filter strips along ditch banks or at field borders can be expected to reduce the sediment carried in diffuse overland flow to the ditch. However, in natural watersheds, flow is concentrated into limited areas. It would be unrealistic to expect a reduction from this practice as high as 46 per cent. Field borders have the added value of keeping the farming operation away from ditch bank slopes, therefore reducing the potential for gully erosion.

A non-vegetative means of removing sediment from surface flow is the parallel, tile-outlet terrace system. Terraces have been installed in several areas of Black Creek Watershed. In some cases they have proved to be more popular with landowners than waterways because they do not drastically interfere with normal farming operations. Terrace systems, which allowing ponding of water and metered flow into a tile drainage system, may remove sediment and related nutrients from runoff. This has not been studied in the Black Creek Watershed although other studies have indicated this is the case.

Evaluations to quantify reduction of sediment that can be expected in a watershed such as the Black Creek Watershed as a result of best management practices have been proposed as part of a continuation of this project.

Tile Flow

The Black Creek area depends heavily on use of tile drainage to allow farming. Wetness is the major hazard to use of soils in the region for farming. This is also true of the Maumee Basin and reflects the recent geological history of the area which was mostly swamp land before it was developed for farming.

As a result, a significant portion of the runoff water from the Black Creek watershed is carried through tile drainage.

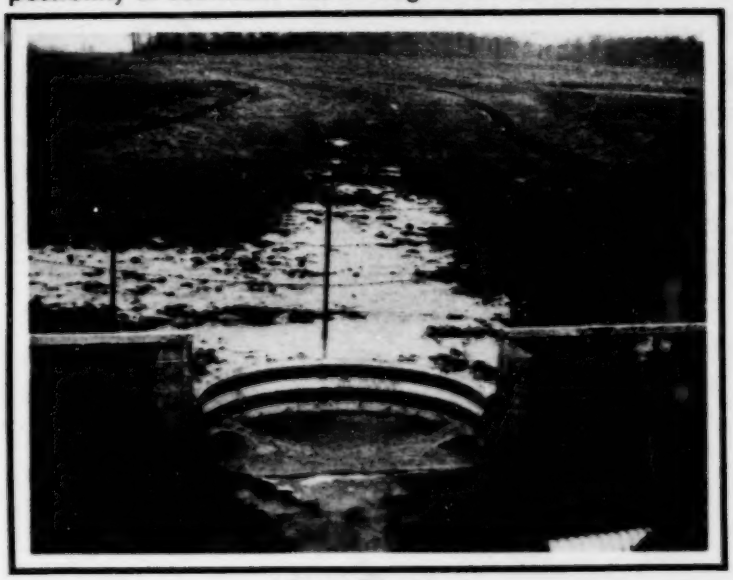
About 11 per cent of the runoff was determined to be attributed to tile drainage. How comparable this figure is to other watersheds depends on the degree of tile drainage necessary in those watersheds.

Most of the pollutants monitored had a lower percentage of total transport in tile drainage water than 11 percent. There was one significant exception —nitrogen in the nitrate form.

About 18 per cent of the nitrate nitrogen was found to be transported in tile drainage as compared with 11 per cent of the total flow attributed to tile drainage. Rainulator studies have indicated that the majority of soluble nitrogen in runoff is derived from fertilizer. Single storms measured in the watershed are capable of removing as much as 2.5 per cent of the total inorganic nitrogen that was applied as fertilizer. This

represents an extreme condition of the intense storm immediately following surface application of fertilizer and should not be considered a normal occurrence.

In samples measured in the Black Creek, the amount of sediment and sediment related nutrients in tile flow would both be relatively low, representing only a few pounds per acre of total sediment. A word of caution should be expressed here, however. Researchers in other areas have predicted that as much as 50 per cent of the annual sediment loss is coming through tile outlets in those areas. Although this does not seem to be the case in Black Creek, the possibility of sediment loss through tile lines remains.



Drop Structure

In addition, some tile outlets carry both surface water and subsurface drainage water. If surface water is introduced into the tile line, the pollutant loads at the outfall will reflect the composition of surface water as well as tile flow. This same situation can pertain if a tile is broken or is functioning improperly so that surface water can leak into the tile drainage system.

Subsurface Runoff

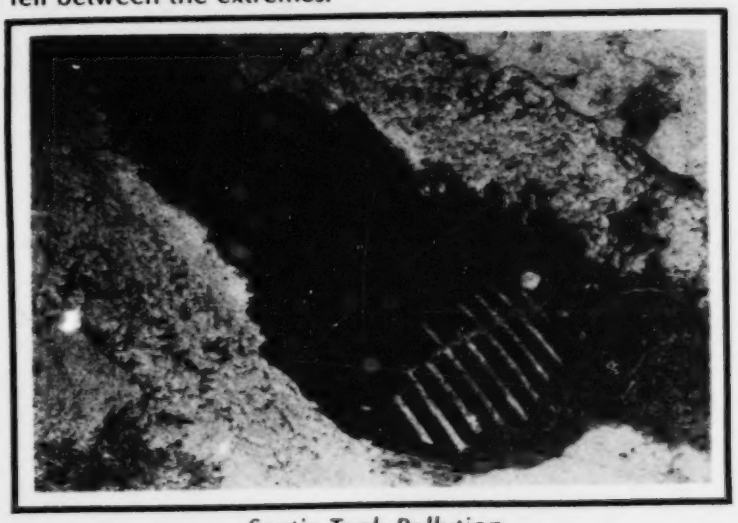
Drainage water which is not surface runoff or tile flow can be attributed to natural subsurface drainage. At a typical site in Black Creek Watershed, about 16 per cent of the total flow was assigned to this source. Again, only nitrogen in its nitrate form was found to be more concentrated in subsurface flow. From 9-50 per cent of the total nitrate nitrogen was determined to be carried in subsurface flow. Smaller amounts are carried during years of greater total rainfall.

Conclusions arising from these studies are the following: (1) An impact on total phosphorus loadings can be obtained by controlling sediment. (2) Nitrates cannot be controlled by controlling only sediment. This implies the advisability of different management techniques if the eventual destination of the water is a eutrophic lake, like Lake Erie, where phosphates are perceived as a major problem or if the eventual destination of the runoff water is a public water supply reservoir.

Flow during the Storm Event

Most sediment and nutrients transported in an agricultural watershed are associated with storm events. For the year 1975, an analysis was made of the amount of water, sediment, and related nutrients that were transported during periods of regular flow, those that were transported during "small storm events" and those that were transported following "large storm events."

For analysis, base flow periods were defined as those during which the flow in Black Creek was 5 inches or less. Large events were defined as any storm that would produce more than 1 inch of runoff. Small events were those which fell between the extremes.



Septic Tank Pollution

Throughout a two year period, base flow occurred on most days. Only three events that could be classified as large events took place.

The majority of water and of the pollutants monitored during two years in the Black Creek watershed were associated with these three large events. About 50 per cent of the total flow and from 73 to 86 per cent of the sediment occurred from these large events.

These events are more intense than the normal rainfall to be anticipated in the watershed. Sufficient data do not exist to determine a statistical frequency for a storm which produces one inch of runoff from the Black Creek Watershed. However, it is assumed that they may represent storms of which no more than one per year could be expected.

The data indicates that the critical factor in determining erosion is very dependent on storm intensity. In general, it has been concluded that land use, including tillage systems and the types of structural practices that are applied, determine the amount of sediment produced for small storms and "normal" rainfall events. When storms become more intense, slope and slope length, regardless of the type of land use, is critical in determining the amount of erosion that will occur. Even under severe storms, however, land use intended to control erosion will have some impact.

Flooding Following Major Rainfall

The implication is that as storms increase, in duration and intensity, more sediment is detached. A single storm of nearly 100-year frequency produced about 50 per cent of the sediment load for the year in which it occurred. Total sediment loadings were higher during the year which had the major storm.

Methods of sediment control relating to large storms have not been demonstrated as cost effective. However, costs of achieving additional control rise faster than does the amount of control possible. It seems reasonable, therefore, to aim

programs of best management practices toward achieving control of the pollution associated with normal rainfall events, leaving a decision about large event related pollution until later.

From the standpoint of water quality in the stream itself, however, low flow or base flow periods are important. Although the total amount of material is greater during a storm event, actual impact of key nutrients may be greater during periods of base flow.

Nuisance algal blooms in Black Creek have been most prevalent during base flow periods. Microbiological sampling has revealed concentrations of fecal coliforms and fecal streptococci in Black Creek waters during low flow periods. At some low flow periods, most of the flow in Black Creek is associated with septic tanks.

If a problem being considered has to do with the water quality in a specific stretch of stream or in a lake, practices to achieve control will have to be concerned with low flow concentrations as well as storm event loading of material. Another way of saying this is that concentration of pollutants is the most appropriate measure of water quality in a stream itself. Concentration and flow, which together allow calculation of loadings, are required to determine the impact of the stream on another body of water.

These considerations lead to the second important observation which can be made concerning the dependence of total transport on the type of runoff event under consideration.

Regular sampling of a stream, without regard to storm events, will produce a good picture of water quality in that stream. It will not produce an adequate picture of the impact of the stream on the bodies of water into which it eventually flows.

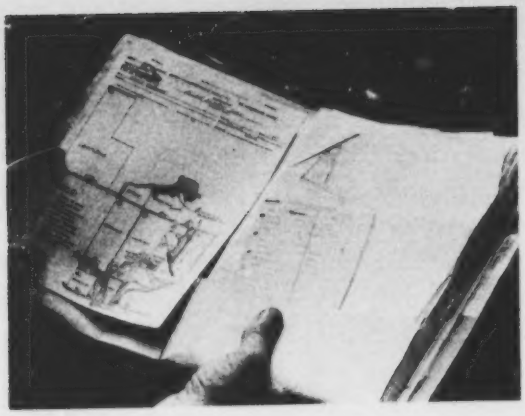
To adequately assess the impact of individual tributaries such as Black Creek on the Maumee River and Lake Erie, it is necessary to have a picture of the loadings as well as the concentrations. To accomplish this, samples must be taken during storm events at appropriate intervals, In addition, flow measurements must be coordinated with individual samples. Periodic grab sampling, (since most of the samples would be taken during base flow) does not provide an adequate base from which to access nutrient transport.

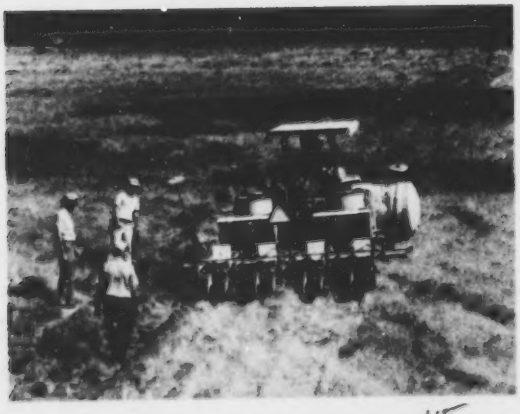
In order to deal with this problem, a system of automated samplers was installed in the Black Creek Watershed. These samplers, obtained from the General Services Administration, are designated as PS-69 samples. They became operational in February, March, and April of 1975.

The automated samplers are energized when the water

stage moves above the base flow (5-inch) level. When they are operating, the samplers collect a sample every thirty minutes. This allows adequate observation and analysis of loadings.

In general, the data indicates that both nutrients and suspended solids increase with increasing flow. More importantly, the nutrients and suspended solid concentrations also increase with increased flow with the exception of ammonia and nitrates which have been previously discussed.





4

LAND TREATMENT

A PART OF THE MANAGEMENT SYSTEM

4

Land treatment describes how the land is being used. The phrase is used to describe the range of management choices made and applied to parcels of land under individual ownership.

The concept of "best management practices" or BMP's as applied to the goals of Section 208, refers to the adoption of those land treatment practices which are expected to have a beneficial impact on water quality.

SCS has several precise definitions to describe the status of land from the standpoint of soil and water conservation programs. An understanding of these definitions is essential to an understanding of the discussion of the program of land treatment carried out in the Black Creek Project.

The definitions from the SCS *Technical Guide* follow:

LAND ADEQUATELY TREATED - Land used within its capability on which the conservation practices that are essential to its protection and *planned* improvement have been applied. This applies to land on which SCS has provided technical assistance.

LAND ADEQUATELY PROTECTED - An estimate of the total acreage of land which the soil, water, and related plant resources are adequately protected. It represents an estimate of all the land within a reporting area on which the soil, water and plant resources are adequately protected from deterioration, either naturally or by action of the land user with or without SCS assistance.

In general, the amount of land adequately protected in a watershed will be greater than the amount of land adequately treated. This is because land adequately treated will always be adequately protected. Some land, in almost any watershed will not need treatment to provide proper protection. In addition, some adequate protective measures may be installed without regard to a formal plan developed with SCS assistance.

Management practices for soil and water conservation can be viewed as being composed of those which are essentially structural and those which are essentially cultural. For purposes of this discussion, practices falling in the first class (structural) include such things as channel stabilization, erosion control structures, grassed waterways, or terrace construction.

Nonstructural practices involve things such as altered rotations, alterations of tillage, and crop residue management.

Practices such as the establishment of field borders involve both structural and nonstructural aspects.

Economically, the two classes of practice are distinguished on the basis of both initial cost and recurring cost. Structural

practices are characterized by a relatively high initial cost (the cost of constructing the practice) and lower annual costs, representing maintenance costs..

Cultural practices, such as the alteration of tillage systems or the removal of land from production for some purpose have a recurring annual cost based on the value of production lost through the application of the practice. These costs in agricultural situations are dependent on the costs of inputs to farm production and the value of farm products to be sold. In the event of a stable price and cost of production, the costs would be the same from year to year. On the other hand, there is usually not a high initial cost unless adoption of the practice requires capital investment in special farming equipment.

A practice such as the installation of a field border involves both the initial cost of establishing the practice, and the annual cost in terms of lost production and of maintaining the practice.

Costs and benefits are much easier to visualize when they are associated with structural practices. Many farmers have expressed a desire to utilize structural practices, even with a high initial cost, to solve particular soil or water conservation problems rather than incurring an obligation to seriously alter farm operations.

In a slightly different connotation, the comparison of grassed waterways and parallel tile outlet terraces is instructive.

Often, grain farmers have preferred the system of terraces to the installation of a grassed waterway. This is because terrace systems take less land out of production than do grassed waterways. The terrace systems used in the Black Creek Project are suitable for inclusion in crop land. By the nature of their design, they do not interfere with the use of heavy farm equipment. Soybeans or corn can be grown on the slopes of the terrace and there is no need to interrupt plow or planter operation to avoid damaging the waterway.

Terrace systems are more costly than a comparable grassed waterway, a factor somewhat mitigated in Black Creek through cost sharing. However, terrace systems have also been installed in other parts of Allen County as a result of the Black Creek project experience. This was done without high cost sharing payments.

Farm operators will readily accept land treatment programs into farming operations if the land treatment does not have an excessive initial cost and does not interfere with present or future profit potential, and if it does not unduly complicate farm work.

4

PLANNING FOR CHANGE IN THE BLACK CREEK WATERSHED

When the Black Creek Project was begun, the Black Creek Watershed had already participated in soil conservation through the regular programs of SCS, ASCS and the SWCD. According to SCS estimates, about 24 per cent of the project area was "adequately treated" and about 36 per cent was "adequately protected."

The planned land treatment program developed for Black Creek had two major goals. These were:

1) To test as many as possible of the standard techniques of soil conservation to discover what their impact might potentially be on water quality.

2) To bring as much as possible of the land in the watershed into the "land adequately treated" category.

Although development of the project has eliminated several of these practices as "best management practices" for Black Creek and the Maumee Basin, it is useful to provide a discussion of those practices considered when the project was in the planning stage.

STRUCTURAL PRACTICES

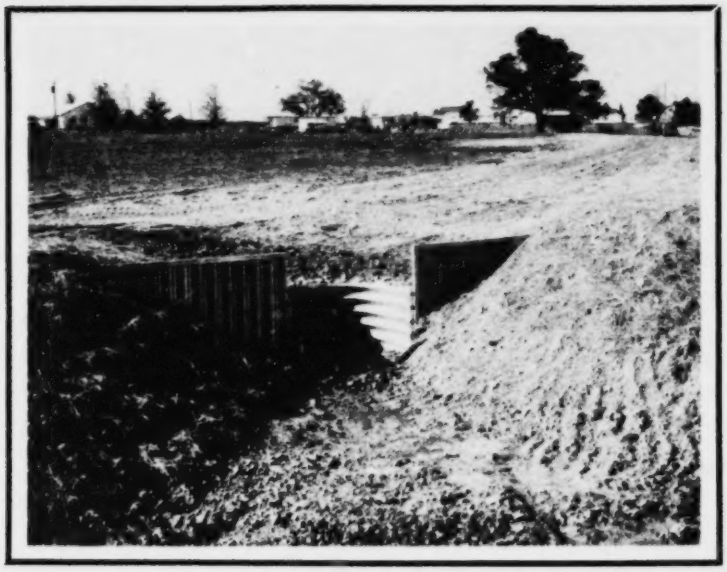
Practices which are primarily structural, and which primarily involve a one-time cost of installation are discussed in the following paragraphs:

DIVERSION — A diversion is a combination of a channel with a supporting soil ridge on the lower side. The practice is always installed across the direction of water flow which means that it will be built across a slope. Diversions serve to reduce the length of slopes and to channel surface runoff water to a place where it can be safely discharged into the drainage system. A primary purpose is protection of land below the slope.

GRADE STABILIZATION STRUCTURES - Grade stabilization structures are designed to stabilize the grade or to control cutting in natural or artificial channels. They are essentially designed either to reduce any sharp change in grade or to provide a stable area at which the change in grade takes place. Abrupt changes in grade produce stream bed or stream bank erosion.

GRASSED WATERWAYS - Grassed waterways have been discussed previously in this report. Specifically, a grassed waterway is designed to carry surface runoff. Waterways are shaped or graded and established in vegetation suitable to prevent erosion of the area over which the runoff water is flowing. Water from field drainage, from a diversion, from a terrace, or from some other structure may be carried in a grassed waterway.

HOLDING PONDS AND TANKS - Holding ponds and tanks are associated with animal agricultural operations. They are either fabricated structures, such as concrete tanks, or earthen structures made by constructing a pit, dam or embankment. The practice provides an area in which animal or other agricultural wastes may be safely stored pending proper disposal.



Grade Stabilization Structure

Livestock Exclusion

LAND SMOOTHING - Land smoothing is done to remove surface irregularities. It can simplify the flow of water in a small drainage area, allowing for better control of surface

runoff when used in combination with some other practice such as a diversion. Land smoothing may also improve the ease with which a particular tract of land can be farmed.

LIVESTOCK EXCLUSION - Livestock exclusion usually amounts to fencing open drainageways or natural streams so that livestock cannot graze banks when there is flowing water in the drainage ditch. Livestock exclusion simplifies the maintenance of drainage streams and at the same time reduces a source of soil erosion. The term is also applied to exclusion of livestock from woodlands.

LIVESTOCK WATERING FACILITY - When livestock are allowed to use drainage ditches or other open channels as a source of water, channel damage is probable. Watering facilities are often constructed in combination with livestock exclusion to provide a source of drinking water for the animals fenced out of stream channels.

PONDS - Ponds are simply water impoundments made by constructing a dam across a waterway or at a natural basin, or by excavating a pit or dugout.

SEDIMENT CONTROL BASINS - Sediment control basins are formed by the construction of barriers or dams across waterways, by the shaping of the bed of the waterway, or through the excavation of a basin and the routing of water from a waterway through it. The basins are designed to slow down the flow of drainage water, allowing sediment and related nutrients to settle out.

STREAM CHANNEL STABILIZATION - Both natural and man-made stream channels may be unstable due to soil type, configuration, or flow gradient in the stream. Stream channel stabilization is accomplished through suitable structures.

STREAM BANK PROTECTION - Unstable banks of streams or excavated channels are protected either through the use of vegetative cover or through structural activities such as plating of the bank with stone or similar material.

SURFACE DRAIN - Surface drains differ from grassed waterways in that no vegetative cover is established. Surface drains are possible when grades and slopes lengths are small. The area is graded to collect excess water within a field and allow the water to flow to a suitable outlet.

TERRACE, GRADIENT - Gradient terraces are earth embankments or ridges with a channel constructed across the slope at a suitable spacing and an acceptable grade to reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet.

TERRACE, PARALLEL - Parallel terraces represent a series of terraces constructed across the slope at a suitable spacing and grade to reduce erosion. In the Black Creek Project, a

special type of parallel terrace was constructed, the parallel tile outlet terrace. In this case, water collected behind the terrace is allowed to flow into a tile drain through an orifice of measured size. Flow, and consequently the time that water is detained behind the terrace, is determined by the size of the orifice.

TILE DRAINS - A conduit, such as a field tile, pipe, or tubing is installed beneath the ground surface to collect and convey drainage water.

CULTURAL PRACTICES

CONSERVATION CROPPING SYSTEMS - Any combination of cultural and management measures which reduces erosion on crop land can be classed as a conservation cropping system. Specifically, cultural measures that relate to this purpose include establishment of crop rotations which contain grasses and legumes as well as rotations which obtain desired soil loss reductions without the use of such crops.

CONTOUR FARMING - Soil erosion can be reduced if sloping cropland is farmed in such a way that plowing, preparing and planting and cultivating are done on the contour lines rather than up and down the slopes. The practice includes farming along the established grades of terraces, diversions, or contour strips.

CROP RESIDUE MANAGEMENT - The residue of crops such as corn and soybeans are left on the surface or otherwise managed to protect cultivated fields during critical erosion periods.

MINIMUM TILLAGE - The number of cultural operations are reduced to those that are essential to produce a crop and prevent soil damage. (In Black Creek this was defined to mean one fall tillage, one spring tillage, one cultivation and no moldboard plow.)

PASTURE AND HAYLAND MANAGEMENT - Pasture and hayland can be protected through proper grazing, adequate but not over fertilization, and reseeding where necessary. The practice is intended to be applied to permanent pasture.

PASTURE AND HAYLAND PLANTING - Long-term stands of perennial, biennial or reseeding forage plants are established to provide livestock food and protection from soil erosion.

STRIPCROPPING - Crops are grown in a systematic arrangement of strips or bands to reduce erosion.

WOODLAND IMPROVED HARVESTING - The potential for harvesting of timber from woodlands is improved through the removal of some of the merchantable trees from an immature stand to improve the conditions for forest growth.

WOODLAND IMPROVEMENT - Wooded areas are improved from the standpoint of timber production by removing unmerchantable or unwanted trees, shrubs, or vines.

WOODLAND PRUNING - Wooded areas are managed to improve timber development by the removal of all or parts of selected branches from trees. strips or bands to reduce erosion.

COMBINATIONS OF STRUCTURAL AND CULTURAL PRACTICES

The following practices are designated as having both structural and nonstructural elements because land involved in the practice is either taken from crop production or its use is otherwise changed in such a way that an annual cost of the practice, in excess of the cost of establishing it, can be assigned.

FARMSTEAD AND FEEDLOT WINDBREAKS - A windbreak is a belt of trees or shrubs established next to a farmstead or feedlot. Windbreaks have the purpose of reducing wind caused erosion and, in the case of farmstead and feedlot windbreaks, of providing protection to dwellings or to livestock from winds.

FIELD BORDER PLANTING - A border or strip of vegetation is established at the edge of a field by planting or by converting trees, to grasses or shrubs. Borders are particularly important when established along waterways. Land involved in the border is permanently removed from crop production.

FIELD WINDBREAKS - Field windbreaks have the same function as farmstead windbreaks. Their primary purpose is to prevent wind erosion from tilled fields.

TREE PLANTING - Trees are planted on land which was formerly in some other use. This practice has a potential cash return when the trees mature and can be harvested.

PROTECTION DURING DEVELOPMENT - Plans are developed to control erosion and sediment during construction of facilities including new homes, new commercial or industrial buildings, new community projects or during road or utility construction.

RECREATION AREA IMPROVEMENT - Specific areas for recreation are improved through planting of grasses, shrubs, trees or other plants, or through the managing of trees and shrubs.

WILDLIFE HABITAT MANAGEMENT - Habitat for wildlife is retained, managed or created. The practice is applied in both upland areas and in wetlands. When the practice involves removal of land from crop production, a recurring annual cost is incurred.

4

PUTTING THE PRACTICES TOGETHER— THE CONSERVATION PLAN

The key to putting practices into place on individual farms is the conservation plan. For a practice or set of practices to be included in a conservation plan, the practice must be suited to the individual situation. In the absence of regulatory or enforcement powers, it must also be accepted by the owner.

In Black Creek, landowners who agreed to participate entered into a contract with the soil and water conservation district based on the conservation plans which had been developed. To be eligible for payments on any of the practices, the landowner had to agree to carry out other practices that were specified in the plan, even if these practices did not involve cost-sharing payments.

Map in Conservation Plan

Early plans were elaborate, offering detailed lists of alternatives. It is now believed that many of these plans may have been misunderstood by participating landowners. In addition, landowners in some cases either did not understand the contractural nature of the agreement they had entered; or, based on previous experience with USDA assistance programs in which compliance was not effectively demanded, did not believe they would be required to comply with the contract.

In order to give all of the conservation practices a fair trial, farm planners assigned to the Black Creek project by SCS were instructed to utilize a complete list of practices in drawing up the conservation plans. It is now believed that an attempt to include as many as possible of the practices in Black Creek probably weakened the overall land treatment

effort, although it retained the research benefits.

Practices which seem most likely to achieve a maximum impact on water quality in the Black Creek area and, by implication, most of the Maumee Basin, are discussed later. These can therefore be listed as best management practices, for this area. The implications of the selection and application of best management practices can be given a more general discussion.

The goal in developing plans for soil conservation has had, at its base, the concept of conserving the soil resource. The water quality benefits of doing this have been assumed to be a natural consequence of conserving soil resources. If soil is not eroded from farm fields it cannot show up in waterways.

When the primary goal of the program becomes improvement of or preservation of water quality, the list of practices which are adapted to this goal in any given area necessarily is reduced to exclude practices not relating to water quality.

Traditionally, practices such as contour farming and strip cropping have been selected as key management practices to the control of soil erosion. The fact that these practices are not selected as best management practices in the Black Creek area says nothing about the merits of the practice and a great deal about the character of the watershed. The long, steep slopes which lend value to practices such as strip cropping do not exist in the Black Creek Watershed, and there are very few areas in the Maumee Basin which would be adapted to them. In another watershed, these practices might very well be among the most important practices for water quality improvement.

In those watersheds and in the Black Creek area, however, the process of selecting practices to be defined as best management practices is similar.

Before discussing the planning technique, some additional comments about soil conservation programs in general are in order. Specifically, past programs of SCS and ASCS have been entirely voluntary in nature. Within the past few years, several states have adopted or have discussed sediment control laws. The program as carried out in Black Creek represents a middle ground between a sediment control law and a voluntary program. This is accomplished through the device of the contractural arrangement. Although no landowner is obligated to enter into a contract with the district, after he has entered the contract, he is obligated to fulfill it including the installation of practices which are mandatory but on which no cost sharing is issued. There is no penalty or sanction possible against landowners who refuse to participate in the study. Sanctions in the form of refusing

cost sharing payments or even of requiring that money already paid be paid back to the district are present in the contractural program.

It is possible to rank approaches to the installation of best management practices according to the following scheme.

1. Voluntary program — Participation is not required. No penalty for withdrawal from the program.
2. Compliance Standards — Voluntary compliance. Standards but no penalties exist for landowners who do not meet them.
3. Contractural Program — Participation is voluntary. A contractural relationship exists and participants can lose benefits or be required to return benefits if participation is not continued.
4. Compliance Standards — Compliance certification required. Landowners are required to reduce soil loss below certain limits. Compliance is determined by analysis of management practices and strategies. If appropriate sets of management practices are implemented, individual farms are determined to be operating properly. No attempt is made to correlate practices on individual farms with water quality monitoring.
5. Regulation With Monitoring of Water Quality — Agriculturally related pollution parameters of streams and drainageways are monitored. Sanctions are taken against landowners who have drainage water entering those streams at levels above some predetermined level.

In this hierarcy, items 1 or 2 calling for programs of voluntary compliance with predetermined standards rely heavily on education to accomplish their goals. Landowners can be approached on the basis of self- interest, community spirit, etc. Items 4 and 5 are highly enforcement oriented. Landowners can be approached in the basis of the potential penalties inherent in the regulations.

The contractural program, as carried out in the Black Creek Program contains elements of both the voluntary and the mandatory program. As such, most Black Creek planners now believe, it should have contained elements of the regulatory program in its approach. Specifically, elaborate plans, offering many alternatives to the landowner in each element, make it difficult for both the landowner and the administering agency to decide if the plan is being followed. The existence of several options in each element of the plan also tends to obscure the fact that a legal bargain has been struck. Landowners can easily decide to modify the agreement without notifying the administering agency.

Soil Conservation Service philosophy identifies a conservation plan as "record of landowner decisions." The

addition of a contract to those decisions essentially makes the plan a record of landowner decisions which the landowner is now legally obliged to implement.

Work with Black Creek landowners has revealed the need to simplify conservation plans, and clearly spell out, in the event that the plan is being used as a basis for a contract or to satisfy a water quality requirement, which items are required and which items are optional.

The Black Creek project was aided in implementation by an effective program of public information. This program began with the initial Maumee River Conference and was continued throughout the course of the project. As a result, landowners did not believe that work was being carried on in secret and did not fear that the project would be detrimental to them. As a result they were more willing to cooperate than might have otherwise been the case. This type of information effort is considered vital to the process of interesting landowners in cooperating with soil conservation projects, particularly when the primary goal is the improvement of water quality.

Finally, Black Creek planners now believe that plans can be more efficiently carried out if those conservation practices which can be expected to have a maximum impact on water quality — the best management practices -- are identified early in the work. This of course assumes that a relationship between water quality and management practices in a specific region has been established. Although this may not be the case, it is possible to separate erosion control practices from other good practices and to concentrate on these. Planners can then seek to incorporate the appropriate management practices into farm plans. This simplifies both the planning effort and the plan itself.

BEST MANAGEMENT PRACTICES

The concept of best management practices, as pointed out previously, refers primarily to management practices which are believed to have a beneficial impact on water quality.

The following discussion deals both with practices that have been selected by Allen County SWCD as best management practices in the Black Creek Watershed and with practices which have been identified as not representing the best management approach. In addition, some practices about which a question remains are considered.

Field Borders

Nearly 21 miles of field borders have been installed in Black Creek Watershed. The borders are generally strips of sod which are believed to prevent erosion at field margins and also serve as a filter for surface water. Although field borders

do usually remove land from production, they have won acceptance with farmers who use them to gain access to fields or to ditches and streams for maintenance during the cropping season. One farmer commented that the rows of corn or beans that were lost in the border were usually damaged by muskrats or raccoons in any case.

Field Border

In short, field borders are relatively inexpensive to install (the total unit cost was 30 cents per lineal foot), have the potential of reducing sedimentation, and have proved to be popular with landowners.

Rock Drop Structure

Grade Stabilization Structures

Nearly 150 structures have been placed in the Black Creek Watershed at an average cost to the District of about $522. These structures, intended to reduce erosion at areas of a rapid change in grade, such as at an area where a surface drain enters a deeper drainage channel, have proved effective at controlling erosion. The structures are popular with landowners who are aware that serious erosion problems at waterways or surface drains result in a deterioration of the soil resource and a consequent lowering of property value. It is estimated that a rather small portion of total soil loss in the watershed comes from these areas; however, grade stabilization structures have been proven effective in controlling this type of erosion and as a result can be considered as a best management practice.

Grassed Waterway

Grassed Waterways

Slightly more than 60 acres of the Black Creek Watershed have been placed in grassed waterways. The longest of these stretches for nearly two miles through both Amish and non-Amish farmland. Grassed waterways, if properly maintained, provide a surface over which collected surface drainage water can be safely allowed to flow until it reaches an open channel or other suitable outlet. Waterways result in land being taken out of production; however, since the alternatives are an open ditch, a large tile, or a gully, the waterways are often a popular choice. In general, their cost is less than either an open ditch or a buried conduit. Land would be taken out of production if a gully were allowed to form. Grassed waterways do not remove large amounts of sediment from surface water. If the waterway filters out large amounts of sediment, it quickly fills and requires further maintenance.

Holding Ponds and Tanks

Holding ponds and tanks are necessary parts of many modern animal waste disposal systems. If the livestock facility is located near a stream or ditch, waste can have a direct impact on water quality. If the facility is located a reasonable distance from drainage ways, the direct impact of the waste on water quality is less certain. If the animal waste operation is large enough, it can probably be classified as a point source rather than a nonpoint source. Proper disposal of animal wastes can in any case be considered a best management practice. When the animal waste operation is located in an area where mismanagement will cause a direct impact on water quality, control techniques can fairly be classified as a best management practice for water quality.

Livestock Exclusion

Fencing or using other means to prevent livestock from entering drainage ways, causing damage to banks and otherwise providing a starting point for erosion, is considered a best management practice in the Black Creek Watershed. Livestock exclusion from woodland is not considered a best management practice for reasons to be discussed later.

Livestock Exclusion

Pasture Plantings

The establishment of permanent vegetation, such as forage plants for livestock feed, has been identified as a good erosion control measure. This is particularly true on slopes and soils which are subject to a significant erosion hazard. Because of the surface cover provided by a permanent grass

crop, the practice is considered to have excellent potential. It is unlikely to win very great acceptance among farmers who are not engaged in livestock production, however. Only 10 per cent of the goal for this practice was reached in the Black Creek Project.

Sediment Control Basins

Two sediment control basins were constructed in the Black Creek Watershed. The amount of sediment trapped by the basins and its composition have been carefully monitored. Sediment has been trapped in both structures and the conclusion has been reached that they are effective for this purpose. Basins have the drawback of potentially taking land out of production. If the basin functions effectively, some sort of periodic maintenance program will have to be established or the basin will quickly fill with sediment, thereby destroying its effectiveness. Basins can, however, be developed for recreation purposes without interfering with their function. They therefore are potentially acceptable to landowners seeking a private swimming or fishing area.

PTO Terrace

Terraces

Systems of parallel tile outlet terraces have been accepted in the Black Creek area. In fact, terraces are one of the few practices on which the project goal was exceeded. No investigation of the precise impact of terraces on water quality in Black Creek have been completed. However, favorable results are expected. Early terrace systems in the project had problems with wildlife. Muskrats destroyed

plastic pipe which had been used for the drains and chewed holes in orifice plates, thereby interfering with the system's capacity to meter the flow of water. These problems are expected to be solved by the use of galvanized pipe for risers and by the use of suitable animal guards at the downstream end of the system to prevent rodents from entering.

Terraces can replace grassed waterways, preventing erosion by reducing the effective slope lengths. As has been noted, they are also expected to remove sediment from surface water. Terraces are expensive to install. The initial costs are somewhat offset, however, by the fact that less land need be taken out of production than is the case for grassed waterways.

Channel Practices

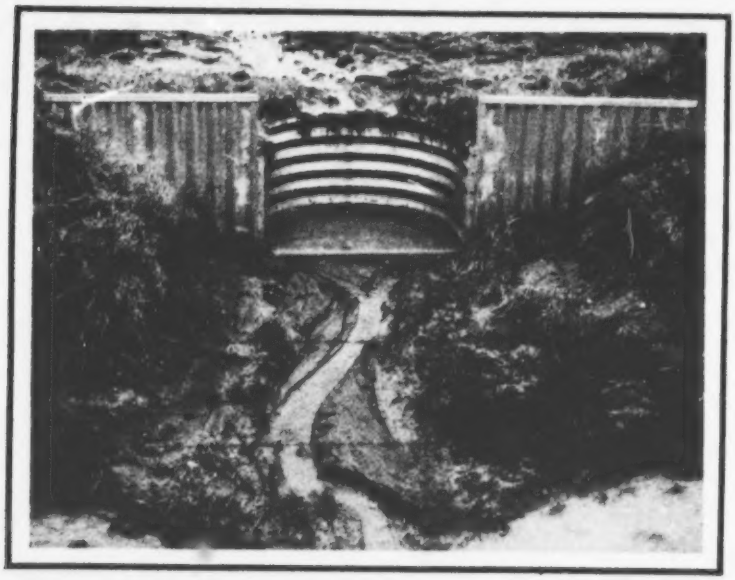
A set of practices involving channel protection, channel stabilization, stream bank protection and related activities can be lumped together. There has been considerable disagreement about whether or not these practices are in fact best management practices in the Black Creek Watershed. The final consensus is that these practices represent best management practices and should be recommended. On the other hand, it has been determined that they represent best management practices under rather narrowly defined conditions.

Single-Side Channel Reconstruction

During the course of the Black Creek Project, about 30 per cent of the funds spent for conservation practices was spent on stream bank protection. This is in contrast to the estimate that only about 3 to 5 per cent of the sediment load can be

attributed to this source. There are two ways to interpret this situation, neither of which is totally true. One way is to argue that more money was spent on stream bank protection and stabilization than was warranted by the seriousness of the problem. The other way is to argue that some methods of erosion control are more expensive than others, but that we are at least confident that we know how to achieve erosion control by ditch bank protection and channel improvement.

The truth probably lies somewhere between these extremes. Areas of great instability along ditch banks contribute sediment to flowing streams. It is the general consensus that methods to check erosion at these critical areas are a best management practice. There is a tendency, however, to approach the problem of bank or channel instability in a comprehensive manner, reconstructing large areas of channel to get at a single area of instability. This approach is largely cosmetic and cannot be reasonably considered to have a major impact on water quality. In fact, studies in a small wooded area along a Black Creek tributary, the Wertz Drain, which was a prime candidate for reconstruction in early stages of the project, indicate that natural channels may have some value as sediment traps under certain conditions.



Erosion at Reconstructed Area

The Wertz Drain through the Wertz Woods is a meandering channel which would normally be identified as in need of reconstruction. However, there are indications that sediment is actually settled out of the drain during

periods of low flow and following small storm events in the Wertz Woods. The woods appear to function as a natural sediment trap during those conditions. Whether sediment that is deposited under conditions of low flow and small event runoff is later picked up and moved on into the Black Creek and Maumee River following large events has not been established, although some investigators believe this to be the case. Sediment transported in this way is, however, less damaging to aquatic life in Black Creek than is a continual higher concentration.

Some areas in which stabilization measures were applied have remained unstable. Others may be more unstable following reconstruction than was the case before work was begun.

Drainage is, however, a key concern for maintaining crop production. Reconstruction and stabilization of drainage channels does have a land drainage benefit and may, in some cases, be necessary to allow farming of the land. Major reconstructions have more of an impact on aquatic life and on water quality than does the performance of regular periodic maintenance performed selectively so that the minimum work is accomplished at any one time. Careful periodic maintenance by individual landowners must be classified as a best management practice.

This discussion also ignores the fact that the highly visable work on stream channels and ditch banks were very important to securing cooperation on the balance of the work undertaken in the project. It is the belief of the Allen County SWCD Board of Supervisors that the amount of land treatment achieved would have been significantly less if the channel work had not been undertaken at the beginning of the project.

The conclusion is that channel and bank stabilization are useful practices when applied only to areas of obvious instability in drainage ways where serious erosion is taking place, for the purpose of improving or maintaining drainage, or for the purpose of securing cooperation on the total project.

Practices in Combination

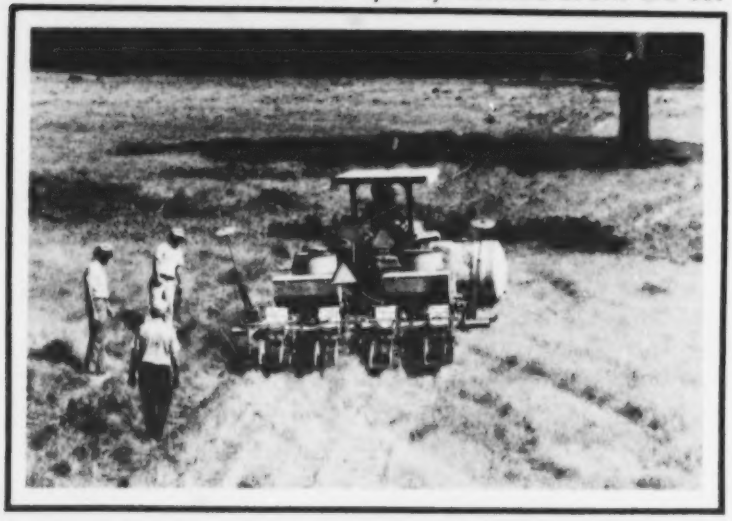
Some practices, such as tile drainage, the construction of surface drains, and the construction of diversions are believed to be primarily production oriented in the Black Creek Watershed. In most cases, in the poorly drained areas of the Black Creek and the Maumee Basin, practices which improve drainage will pay for themselves in terms of consistent improvement in crop production. These practices cannot, therefore be labeled best management practices for Black Creek, unless their installation is necessary to carry out

some other practice. For example, grassed waterways can usually not be established unless there is sufficient underground drainage to prevent wetness from damaging the grassed cover. The solution is a tile drain underlying the waterway. In this case, since the tile drainage is necessary to establish the waterway, tile drainage can be considered a best management practice.

Terrace systems, as established in Black Creek require tile to be installed to provide an eventual outlet for water impounded by the terrace system. Tile drains in terrace systems are therefore also considered a best management practice.

Cultural Practices

As has been previously discussed, the use of tillage systems which leave cover on farm fields and which increase the surface roughness of those fields are considered good practices for water quality enhancement. To understand the implications of these techniques, the typical farming methods of non-Amish farmers in the Black Creek area are outlined here. When water quality considerations are set



Planting in Sod

aside, the management practices which most farmers believe will produce the best return on farm land in the area involve fall moldboard plowing. The moldboard plow is the traditional implement of soil preparation on Corn Belt farms. Its operation results in the soil being turned so that surface debris is buried. Fall moldboard plowing would normally be followed by two or three more shallow tillage operations in the spring with a disk, field cultivator or harrow. Planting would be followed by one or two cultivations for weed

control at the appropriate stage of development for row crops.

This tillage sequence leaves the soil uncovered during the season of maximum potential soil loss, late winter and early spring.

A more acceptable method, from the standpoint of water quality, is to replace fall moldboard plowing with fall chisel plowing. Unlike the moldboard plow, the chisel plow does little turning of the soil. Significantly more residue is left on the surface. Fall chisel plowing, is followed by spring tillage much as has been outlined for fall moldboard plowing.

Moldboard Plow

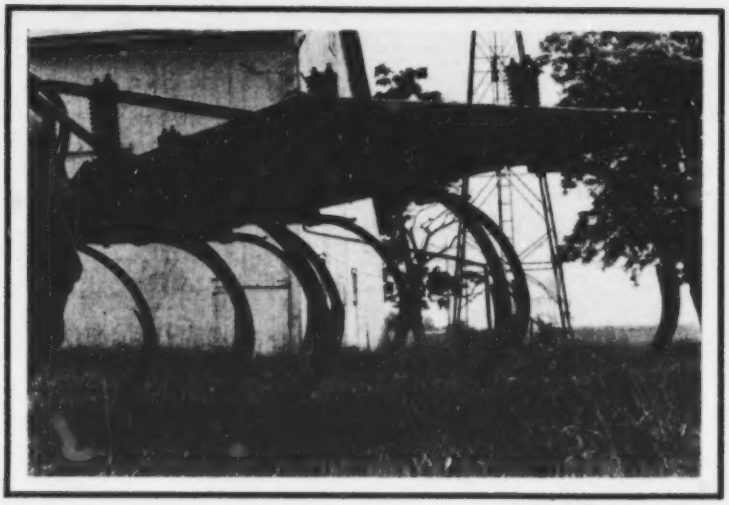
If a determination is made to spring plow rather than fall plow, residue is left undisturbed on the surface for a large part of the winter. Spring plowing is usually done with a moldboard plow, since roughness left by spring chiseling makes seedbed preparation more difficult. Shattering compacted plowsoles is often possible with full chiseling, but seldom possible in the spring due to increased soil moisture.

In further reduced tillage systems, plowing is eliminated and field preparation is by disking only, or by some combination of the disk and field cultivator. Generally, tillage depth is reduced and surface residue increased compared to the moldboard or chisel plow.

Finally, a decision may be made to eliminate tillage altogether, except for a narrow 1 to 2 inch band for each row. This is usually called no-till planting, a system which should provide maximum water quality benefit.

In any system of no plow tillage, pesticide usage will necessarily increase. These tillage techniques leave weed seeds nearer the surface, leave residue which interferes with

herbicide activity and provide fewer opportunities to incorporate chemicals or use mechanical cultivation. No-till planting for May-planted soybeans is not recommended in Indiana, primarily due to potential weed problems. Certain insects are also more difficult to control with no-till planting. In general, the more tillage can be reduced, in accordance with the discussion here, the greater will be the beneficial impact on water quality, keeping in mind that benefits will also be greater when the preceding year's crop is corn rather than soybeans. A discussion of the economics of reduced tillage systems is provided later.



Chisel Plow

WOODLAND PRACTICES

No woodland improvement practice has been identified as a best management practice in the Black Creek Watershed. This is because of the relative unimportance of timber production and the lack of interest on the part of landowners in converting land which is capable of producing crops into timber land. In addition, wooded areas within the Black Creek Area are generally flat, poorly drained areas which produce a minimum of runoff and a minimum of potential erosion damage. Practices such as woodland improved harvesting, woodland pruning, exclusion of livestock from woodlands, tree planting, and the establishment of farmstead and field windbreaks should be studied in areas in which woodlands play an important part in the overall land use.

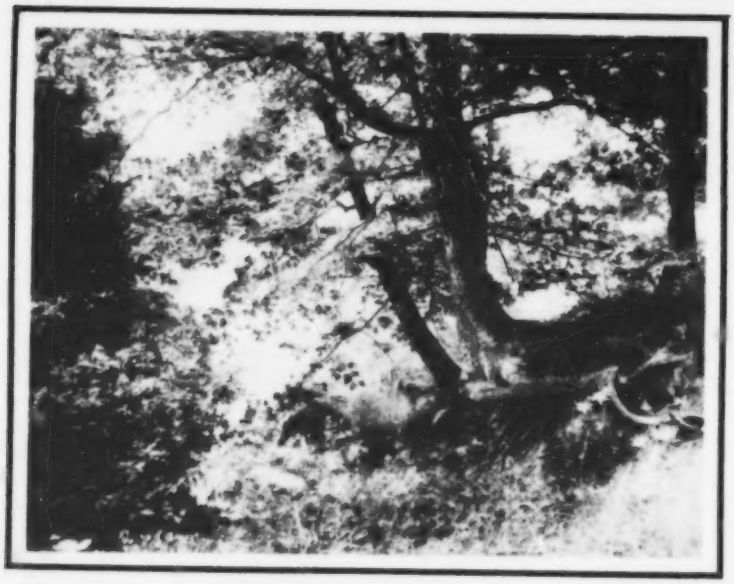
PRACTICES NOT FITTED

Two of the well known management practices of the SCS program, contour farming and strip cropping, are not identified as best management practices in the Black Creek

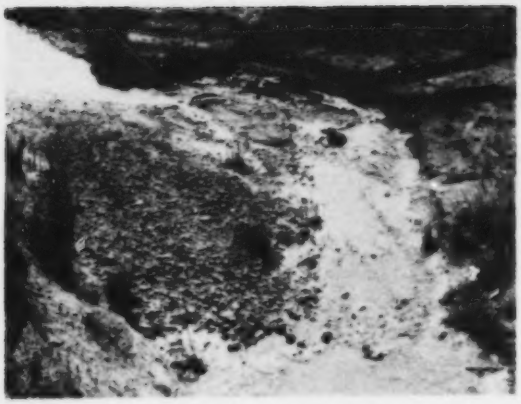
Watershed. These practices are applied to long, steep slopes and have been demonstrated to be quite effective in controlling erosion. They are not recommended in the Black Creek area because the watershed, and by implication the Maumee Basin, does not have areas in which these practices are suited.

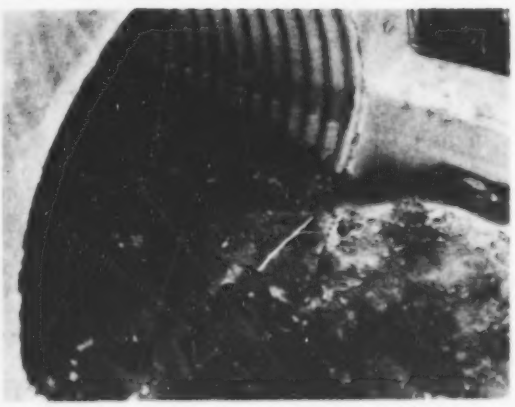
FROSTING ON THE CAKE

Some valid conservation practices — recreation area improvement, pond construction wildlife habitat management — in general have goals other than the improvement of water quality. Although no criticism is intended of the practice *per se* it is the general feeling of workers on the Black Creek project that these practices as applied in Black Creek, served as attractive extras in conservation plans. They provided a frosting on the cake, added to the total conservation value of the plan, but had little impact on water quality.



Wildlife Area





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WHAT'S IT GOING TO COST?

Except in isolated cases, it is doubtful that the type of erosion and consequent sediment production that has taken place in the Black Creek Watershed will have a significant impact on the cash value of individual farms within the lifetimes of the current landowners.

In some other agricultural watersheds, erosion is a more present danger. Cost figures for the Black Creek project are probably therefore low in comparison to potential cost figures for treating erosion and sediment production in areas with more severe slopes and a predominance of more erosive soil types.

In that sense, the Black Creek project represents a final touch up. It can be considered representative of the type of work that might have to be done in another area after the major problems had been dealt with.

In fact, any practical program to control agricultural nonpoint source pollution will combine structural and non-structural approaches in the way which appears to be most cost effective.

Cost data for the Black Creek land treatment program and in the economic model of Black Creek farms are not really comparable. We are forced to consider them separately, recognizing this does not provide the most satisfactory analysis.

The cost information presented here deals with soil loss rather than with water quality, later discussion attempts to relate management practices more directly to water quality objectives. The basis for calculating soil loss and the basis for determining whether or not land is adequately protected is the Universal Soil Loss Equation. The equation is statistically based, it deals with the loss of soil from small fields over time. It is not useful for predicting specific soil loss in a given year and does not attempt to predict whether or not soil which has been detached actually finds its way into waterways.

The equation predicts the annual soil loss per acre in terms of rainfall, soil type, slope length, crop management system, and erosion control practice.

The economic model used established values for the factors involved in the soil loss equation, varying cropping factor to achieve predetermined average soil losses.

Precise values obtained are related specifically to the Black Creek Watershed. Within limits, some general conclusions can be drawn.

Specifically, a linear model was developed to analyze best management decisions and to find those which would provide maximum profit under various soil loss constraints.

Analysis was done on hypothetical farms of two size classifications — 580 acres, representing a "large" farm in

Black Creek, and 370 acres, representing a medium sized farm.

Each was analyzed on the basis of average land slopes of both more than two per cent and less than two per cent. Values for land, labor, and machinery resources cost were based on results of a survey of non-Amish farms in the Black Creek Watershed. Crop management and yield information for these calculations was obtained both from the survey and from other information concerning soil characteristics and crop production. Yield differences associated with various tillage practices were based on previous studies.

When no constraints were placed on soil loss or field operation, the model showed that profits were maximized when corn and soybean land were prepared in the fall with a moldboard plow. One-third of the area was put into corn production while two-thirds went into soybeans. This is consistent with current farming practice as has been previously pointed out, with the exception that corn production in reality is usually greater than the model would indicate.

As the soil loss constraints of the Universal Soil Loss Equation were made more stringent, tillage practices tended to shift from moldboard preparation to more chisel plow preparation.

Implications of the analysis by the economic model are that the preferred tillage practices currently utilized in the Black Creek project are generally practices which tend to maximize profit. A determination to improve water quality by generally mandating chisel plowing methods would have relatively high economic cost.

This form of tillage is not uniformly adapted to all areas in the watershed and may be expected to produce a significant soybean yield reduction if it were applied to the level poorly drained, lake bed soils. However, on the more sloping and better drained soils of the uplands, chisel plow preparation may in fact increase the profit potential. This analysis indicates the difficulty of applying uniform practices for achieving water quality improvement, even in areas as small as the Black Creek Watershed.

The cost sharing approach in the Black Creek involved payment for the installation of specific structural measures. These measure have a one-time initial cost. However, the life of structural practices is not unlimited. Useful life of practices range from about 10 years for terrace systems, through 15 years for practices such as grassed waterways, to as high as 30 years for grade stabilization structures and tile drainage.

The total cost of applying structural practices is composed, in the Black Creek Project, of three elements — the amount

of cost share payment made by the district, the amount of money paid by individual landowners to install the practices, and the cost of technical assistance necessary to design and supervise the installation of the practices. Approximate values in the Black Creek Watershed were: cost sharing $518,000; farmer payments, $150,000; technical assistance, $250,000; a total of $910,000 which averages about $75 per acre for the 12,038 acres in the watershed. Of the $518,000 cost sharing, about $216,000 was for channel practices, or about $18 an acre, leaving $302,000 or about $25 per acre in cost sharing for practices applied on the land.

Benefits of spending this money are uncertain in terms of water quality. However, as has been pointed out, analysis of data collected during the Black Creek Project indicates that for small storms, land use, including the installation of structural conservation measures are the determining factor in soil erosion. In terms of the land itself, this expenditure has resulted in a shift of land in SCS's adequately protected category from 36 per cent at the beginning of the project to 84 per cent at the close of the project.

In other words, assuming an average life of 15 years for conservation practices installed, and not accounting for discount rates but simply dividing the cost per acre by 15 years, a cost of $5 per acre per year could be assigned to structural methods of erosion control. As is discussed in more detail in the next section, it appears likely that water quality can be improved without making this expenditure. Cost of utilizing cultural practices, such as a change of tillage, are dependent on two major factors — the amount of crop yield reduction which accompanies the change in tillage and the market value of the crops produced.

When a significant yield reduction accompanies the change in tillage practice, the dollar cost of sustaining that yield reduction will be higher when farm prices are high and correspondingly lower when there is an abundant supply of farm products and market prices are relatively low.

Long-term studies in the Corn Belt and preliminary results of the tillage research in the Black Creek area indicate that on erosive, sloping soils of the Black Creek uplands, no yield loss is associated with chisel plow preparation for corn. Yield loss data for soybean production is less certain, but is expected to be relatively low. As a result, there may in fact be a potential increase in income associated with certain shifts of technique which are at the same time most associated with improved water quality.

In general, the economic model leads to the conclusion that nonpoint source pollution control associated with soil loss can be more effectively achieved through a policy of

uniform control of soil loss rather than through a policy of requiring uniform practices throughout a watershed.

It is certainly possible to assign lower per acre costs to a program of nonpoint source pollution control from agricultural sources than that assigned the Black Creek project. Such a decision can be based on perceptions of the degree of financial commitment that can be expected within the political system. Estimating the costs to be lower to achieve fixed water quality standards will not in fact make the costs lower, however.

One approach to presenting favorable costs is to count only the cost underwritten by the public through cost sharing or incentive payments and to ignore the costs incurred by individual landowners, either in terms of matching funds or in terms of lost production.

The discussion of costs presented here only touches on the question of whether the improvement of water quality to be gained by providing the level of protection which has been achieved in the Black Creek watershed is sufficient to meet potential water quality goals.

"ANSWERS" TO THE COST QUESTION

The cost analysis discussed previously casts doubt on the economic feasibility of achieving water quality by a program of total land treatment. It should be remembered that there are two basic resources involved in soil conservation-water quality programs. There is the water resource, which has been the subject of most of the discussion in this report. There is also the land resource. The basic programs of SCS conducted over the past four decades have been aimed at preserving this land resource. Recently, SCS programs have come under fire not only from the standpoint of water quality objectives but from the standpoint of success, or lack of it, in preserving the land resource.

The General Accounting Office, in its February 1977 report, points out that even if water quality considerations are neglected, protection of the land resource itself is necessary if the capacity for food production is to be maintained. From another standpoint, when the Black Creek project began, only 26 per cent of the land in the watershed was considered adequately protected while only 24 per cent of the land was adequately treated.

Although it is unlikely that soil loss in the Black Creek Watershed would result in severe deterioration of the land resource within the lifetime of current landowners, it can be expected that the need to produce food and fiber will become more acute over the closing decades of the 20th century.

Certainly there will be periods of economic fluctuation in which one crop or another will be in temporary surplus. This does not eliminate the fact that the thrust must be for continued increase in food production capability if the nation is to meet the needs of foreign markets and indeed if the nation is to continue to feed itself.

The program of total land treatment discussed under the cost section is necessarily a program which has intrinsic merit, regardless of the water quality impact. If soil resources are not to be allowed to deteriorate to the point that production capability is reduced, adequate conservation and cropping measures must be applied. Because of the long period of time which appears to be available in the Maumee Basin before the land resource deteriorates unreasonably, however; the preservation of the land resource is less urgent than new water quality goals, made particularily important by the development of water quality management plans under Section 208, and by the deterioration of valuable resources such as Lake Erie.

Ideally, it might be hoped that water quality improvement measures could be identified which would allow a major impact on water quality to be achieved, even if the total treatment of agricultural watersheds were not achieved.

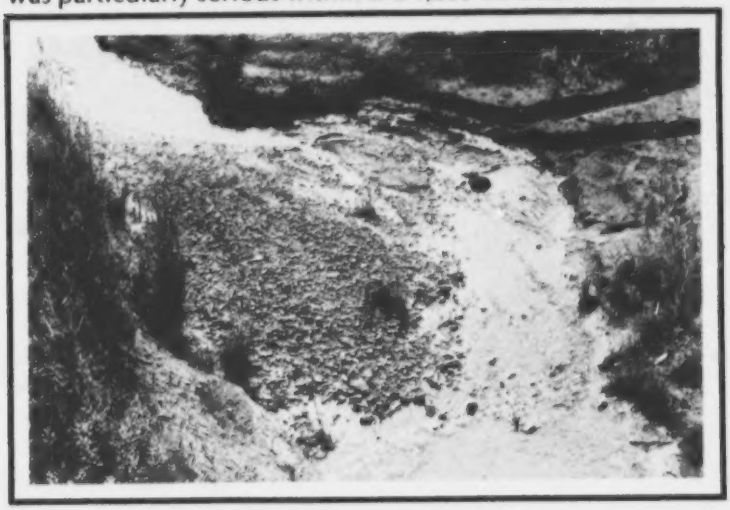
This approach was considered in the economic model and the conclusion was reached that the greatest social benefits could be achieved by concentrating control efforts on only the most erosive lands.

As a part of the effort in the Black Creek project a model, called the ANSWERS model (Aerial Nonpoint Source Watershed Evaluation Response Simulator), of sediment detachment and transport into waterways was developed. It divides a watershed into small parcels (2.5 acre parcels were used for Black Creek simulations) and describes water movement throughout a watershed as it eventually moves into drainage channels.

The model is capable of simulating the movement of sediment and related nutrients. Although attempts are being made to make the model more useful in other watersheds, the model already gives evidence of being a powerful tool for dealing with the specific problem of applying management practices in such a way that the maximum return in water quality can be achieved for the lowest public and landowner investment.

The use of this model to simulate the effect of an actual storm event in a subwatershed of the Black Creek area, allowed comparison of model predictions with actual loadings of sediment into the Black Creek as measured at one of the sampling stations.

The model was able to predict the loadings into Black Creek for this storm within about 15 per cent which is considered an accurate representation. It not only identified total loadings, but also highlighted those areas where erosion was particularly serious within the 1,800-acre subwatershed.



Critical Erosion Area

Since the model takes into account factors such as tillage, it was possible to play a game of "what if" and compare the conventional tillage methods in the watershed with predicted improvements in water quality that could be obtained by using tillage which leads to less erosive conditions.

When the conventional tillage of the watershed was changed to tillage involving chisel plowing, a reduction of two-thirds was obtained in the amount of sediment entering the creek from that single storm. More significantly, however, was a third run of the model, this time comparing the sediment produced when only 80 acres of the watershed, which represent the two most highly erosive areas, were changed from conventional tillage to chisel plowing. This simulation indicated that about 40 per cent of the reduction could have been achieved by treating 80 acres rather than 1,800.

If we go slightly out on a limb and assume that addition of total structural treatment of the 80 acres identified as critical in the model would result in a great enough reduction in sediment to meet water quality goals, then we would predict that treatment (at the $75 per acre cost) need cost only $6,000 for this subwatershed rather than the $135,000 which would be required to treat each of the 1,800 acres.

If we are satisfied with the 40 per cent reduction (about 25

per cent of the total loading) and if we assume that chisel plowing does not represent a significant loss of profit on the soils in question, then satisfactory control can be achieved in this subwatershed with the only costs being capital costs involved in equipment to allow chisel plowing to be done.

From the economic standpoint, this makes achieving water quality goals much more feasible than attempting to treat all of the land in extensive watershed areas in a highly compressed time frame.

It should be noted that this projected ability to achieve large amounts of water quality improvement with relatively small applications of particular practices may be a characteristic of the Black Creek Watershed and the Maumee Basin. The same situation may not hold in watersheds having steeper slopes and more erosive soils.

However, if the Black Creek Watershed is considered to be a watershed in which major erosion problems have been solved, the ANSWERS model is applicable to other watersheds as a finishing touch for water quality management programs.

Future development of the model will allow the incorporation of basic water quality improvement structural practices as well as cultural practices. The amount of data needed in unique date files for the model will be reduced. These efforts also should simplify operation and should reduce the time and cost of utilizing the model. It can be observed however, that even though the model currently requires a sizeable amount of computer time and core space, the computer time and cost represent only a fraction of the time and cost involved in the installation of structural or cultural land treatment practices.

A more complete discussion of the concept and application of the ANSWERS model is contained in the technical volume of the Black Creek final report.

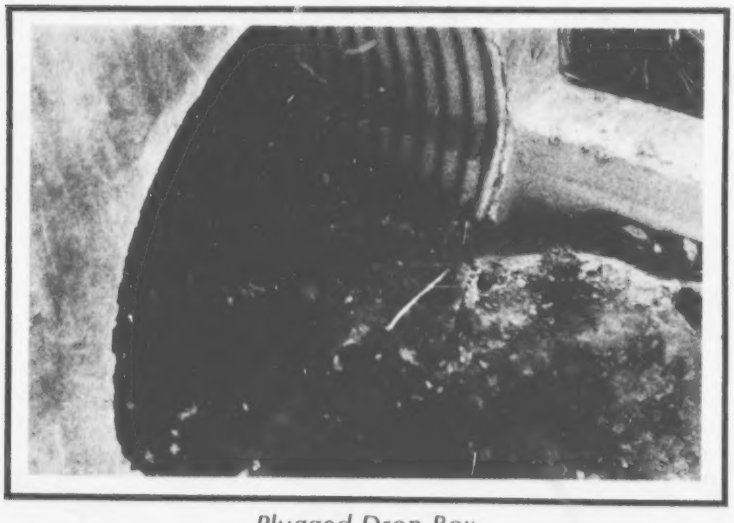
THE MAGIC WORD "FEASIBLE" — WHAT DOES IT MEAN?

Congress, in writing Section 208, included a requirement that area water quality management plans include measures for controlling pollution from agricultural nonpoint sources "to the extent feasible'. One of the key questions facing Section 208 planners, as the water quality management planning process moves into its final phase, is a definition of the word feasible.

The concept of "zero discharge" of pollution cannot be meaningfully applied to all nonpoint sources. The process of erosion, the ever changing face of the land, the twists and turns in geologically new rivers as they cut new channels and

find new paths to their eventual destinations involves erosion.

Improper Solution to Erosion



Plugged Drop Box

Erosion, whether in the Nile Valley, around the "muddy Missouri', or contributing to the formation of the Mississippi Delta, is a natural process. Certainly natural erosion is taking place in the Maumee Basin and was doing so prior to any human interference.

A water quality standard which required no sediment would be defeated by the streams themselves which are capable of picking up debris and soil particles from their own beds when no other material is in the water.

Maumee River

Perhaps the only way to achieve zero sediment would be to pave the stream beds and their surrounding lands, locking soil into place but locking out agriculture, wildlife, and people.

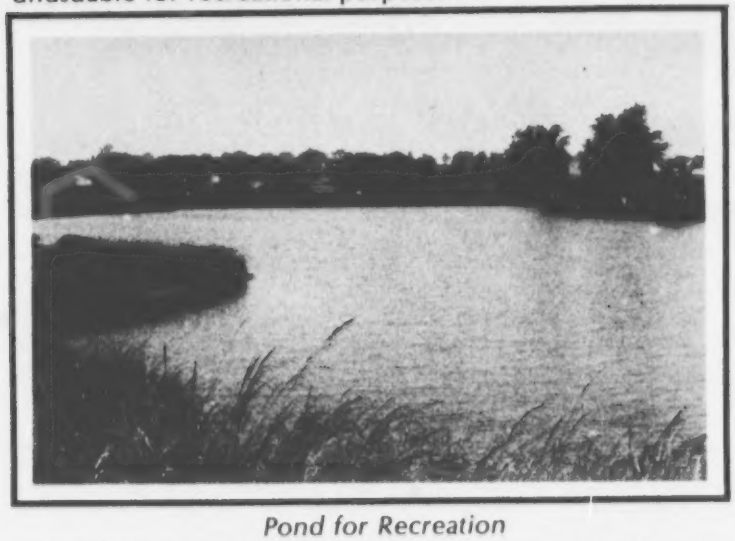
Agriculture, because it involves disturbances in the soil, and because it involves reductions of the natural cover, increases erosion and consequently sedimentation.

Any plan which aims to control pollution from agricultural nonpoint sources must, therefore, be concerned with striking a reasonable balance between the need to maintain agricultural production and the need to maintain or improve water quality.

The possible extremes in the Maumee Basin would appear to be either to aim for maximum crop production without regard to soil or the water resources, or to sacrifice crop production by putting the entire basin into some sort of permanent vegetative cover. Neither of the extremes are likely to be considered feasible.

Although it has been pointed out that agricultural nonpoint source pollution does not readily fit into the "zero discharge" program, levels of pollutants from nonpoint sources will have to conform with the Congressionally mandated requirements for "swimmable and fishable" waters as outlined in Public Law 92-500.

Although swimmable and fishable waters are not precisely defined, it can be assumed that swimmable means that waters are pure enough so that no health hazards are encountered by the emersion of the whole body in the waters. In addition, there is an assumption that waters are reasonably pleasant to enter, are free of odors and appearances that make them unusuable for recreational purposes.



Pond for Recreation

Fishable waters implies that concentrations of pollutants which would interfere with fish life either by directly destroying it, destroying essential links in the food chain or interfering with its reproduction are not present.

In terms of the Black Creek Watershed, the following observations can be made. Nitrate concentrations do not threaten either swimmable or fishable conditions. Nitrate levels, while higher than from non-agricultural watersheds do not reach high enough levels that water quality standards for drinking water are exceeded.

Microbiological parameters — fecal coliform and fecal streptococci — are high enough to interfere with either fishable or swimmable conditions. These levels represent waste loadings, some of which are undoubtedly associated with septic tank operation. Although some of these septic tanks are associated with farm homes, others are associated with nonfarm homes and general residential development in what was previously an agricultural area.

Phosphate levels are high enough to interfere with the use of the water through the promotion of algae blooms. These blooms, result in the addition of organic material to the waterway and result in a net increase in the oxygen demand, thus interfere with fish life and make the Black Creek

unsuitable for some bottom dwelling insects and other invertebrates which constitute a potential part of the fish food chain. Algal pads, referred to by residents of the watershed as scum, would make use of the water unpleasant, even if no health hazard existed.

Septic Tank Construction

Drainage maintenance, particularly if a large number of drains were reconstructed in a relatively long section of the Maumee River would have an impact on the Maumee River fishery through interference with the breeding cycle of several important fish species.

Sediment levels following storm events can be quite high in the Black Creek. Sediment concentrations by themselves do not preclude the growth, breeding, and development of Maumee River fishes, providing the high concentrations represent intermittent events and not the normal levels.

To meet the goal of swimmable and fishable water quality in Black Creek and the Maumee Basin, it is therefore necessary to be concerned with phosphates both in soluble form and possibly as sediment bound phosphorus. In addition, a means of controlling septic tank pollution seems necessary.

Almost any attempt to control sediment pollution would involve economic costs. These costs could be incurred either in terms of initial dollar costs to pay for the installation of structural practices or in long- term costs associated with reduction in production, where this occurred, or removing land from production.

Some combinations of cultural and structural practices would likely be used in any control program.

Fishing Site

Farmers are in a unique economic position in that trade in basic agricultural commodities is done in a relatively free market. Presumably, if controls were imposed uniformly throughout all farming areas, and if those controls resulted in a significant yield reduction, then the price of basic farm commodities would increase. But, in fact, there is no mechanism by which farmers can pass on the cost of pollution control techniques as monopolistic industries do.

Imposition of nonpoint pollution controls would put a more severe financial burden on landowners who farm more erosive soil. Since these soils generally represent land of lower value and support farming operations which are more complex, a competitive advantage would be given to farmers with holdings in non-erosive areas.

Larger farms appear to be better able to incorporate techniques of erosion control into their regular operations with less cash loss. Imposition of nonpoint pollution controls would therefore increase the competitive advantage of larger landowners over smaller farmers.

Subsidies or incentive payments have been used in the past to achieve cooperation of individual farmers in land and

water conservation. The Black Creek Project has demonstrated that when there is sufficient financial assistance available and when there is sufficient technical assistance and local interest, a voluntary program of erosion control with cost-sharing payments can be effective in achieving protection of land from soil loss.

It remains to be seen whether a voluntary program would be equally effective, even with cost sharing payments available, if the permitted soil loss were constrained to more restrictive limits than are currently applied in the Universal Soil Loss Equation.

Because of traditional approaches, *i.e.* cost sharing and voluntary compliance, and because of resistance to regulation in general, it is believed that an approach to agricultural nonpoint source pollution control which involves only a regulatory approach with no public participation in the cost of the program would be extremely unpopular and would be very difficult to enforce. The Black Creek experience leads to the conclusion that a regulatory capability would probably have to exist if a goal of total treatment of the land to reduce pollution from every parcel in a watershed to a fixed level were adopted.

Cost sharing programs have traditionally centered on structural practices because of the ease in which payments can be calculated and because of the ease with which compliance with requirements for the practice can be determined.

In the Black Creek Watershed, several structural practices have been identified as reducing erosion. Only three of these practices have been identified as having much potential to remove sediment from surface drainage water after it has been detached by the raindrop impact. These are sediment basins, terrace systems, and vegetative fields borders.

The most important management practice from the standpoint of improved water quality appears to be the management of crop residue through appropriate tillage methods so that the soil surface is left with at least partial cover throughout most of the year.

In general, it appears to be more popular to provide cost sharing payments for the construction of specific structural practices which, it is hoped, can reduce the adverse impact on water quality. Unfortunately, the maximum impact on water quality may be had by cultural practices which are less easy to administer, to enforce, or to fairly involve in cost sharing programs.

The economic costs, whether paid by individual landowners, by taxpayers, or by some combination of

landowners and taxpayers, will not be trivial if it is decided to attempt to treat every acre of agricultural land so as to reduce agricultural nonpoint pollution below some predetermined level. The ANSWERS model, however, provides some hope that water quality standards can be met by concentrating on identified areas of high erosion. Identification of these areas, hopefully representing a small fraction of the total land area, can greatly reduce the cost of installing agricultural pollution control practices, thereby increasing the feasibility of meeting the substantial economic costs which will be involved.

It is not the purpose of this report to suggest what the policy of agricultural nonpoint source pollution control should be, either for individual Section 208 planning areas, or in the nation.

The following, therefore, represent questions which should be addressed, based on the Black Creek experience, in formulating policies for this purpose.

1. What level of water quality is desired? In general, in the Black Creek Watershed, except for sediment for which no water quality goal has been proposed, only phosphates appear to present a serious control problem from the standpoint of strictly agricultural nonpoint source pollution. Control of phosphates is closely associated, however, with control of sediment.

Erosion Control

Level of control of sediment and sediment related pollutants must be specified in terms of specific types of

storm event. Sediment production associated with small storm events could well be controlled, but large events and particularly rare severe storms would still produce heavy sediment and pollutant loads. It should be remembered that costs will increase greatly as control measures are designed for storms of increasing intensity. At some level of storm intensity, control measures are probably impossible, even if economic considerations are totally ignored.

2. How can the program be made fair? A traditional approach to water quality management planning is a desire to treat everyone alike. This report has made it clear, however, that programs which treat everyone alike by specifying practices which must be installed or by requiring specific tillage methods throughout the planning area will have not only greater total costs than more selective approaches, but will work a greater economic hardship on landowners whose land is unsuited to the required practice.

3. Who should pay the costs? Because farmers have no mechanism of passing on costs, the only method by which the public can pay a portion of the costs of achieving water quality standards by reducing nonpoint source agricultural pollution is through cost sharing or incentive payments.

Incentives or subsidies can be used either to try to strike what is perceived to be an equitable balance of cost distribution or to encourage landowners to take part in voluntary programs by payment rather than by enforcement. If it is determined that cost-sharing payments should be made to encourage voluntary participation, should cost sharing rates and cost sharing funds be channeled to those landowners who have the greatest problems, or should the funds be distributed uniformly throughout a planning area?

Should cost sharing be limited to structural practices, representing the more traditional approach, or should cost sharing funds be offered for cultural practices where these seem most appropriate?

4. What kind of enforcement is appropriate? Should landowners be convinced to participate in the program through incentive payments, through prosecution in the courts, or through some combination of these approaches. Should the prime enforcement agent be the EPA, state government, or local government? How can compliance be determined either for enforcement or for cost sharing?

5. What are the other consequences of the program? Any program of nonpoint source pollution control applied to agriculture will have an impact on land values and other costs of production. In most farming areas, reduction of farm income will have an impact on the economy of the entire area. What are these impacts and what weight should be

assigned to them in designing a program of nonpoint source pollution control?

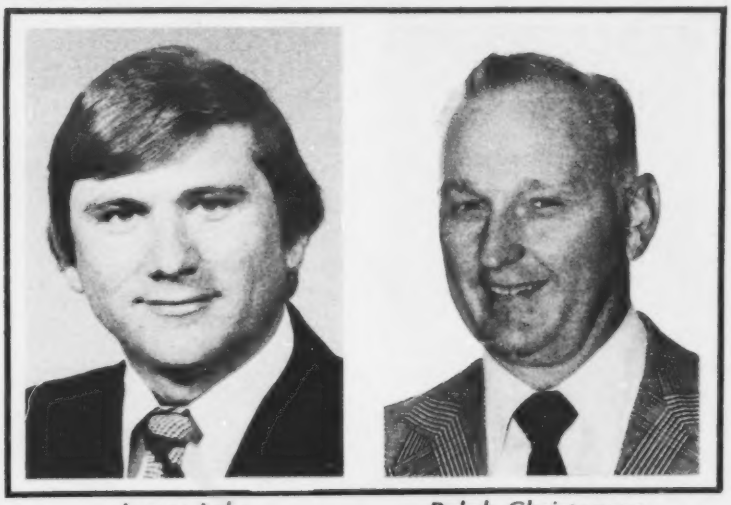
The answers to these six questions can move planners closer to the definition or the term "feasible" as it relates to control of pollution from agricultural nonpoint sources.

6

KEY PERSONNEL

The Black Creek project has depended for its success on cooperation among personnel representing governmental units and agencies. Divergent viewpoints and interests have often required resolution before work on the project could go forward. Two mechanisms were utilized to assure communication between members of the project staff and to assure communication between the project administration and the landowners who live in the watershed.

First, monthly meetings of a steering committee have been held, usually either at Purdue University or in the watershed but sometimes at the State Office of SCS in Indianapolis or at the Region V office of USEPA in Chicago. These meetings, conducted by project administrator James Lake were useful not only from the standpoint of communication but also from the standpoint of allowing decisions to be made concerning project goals and directions after consideration of the opinions and expertise of the various specialists involved.



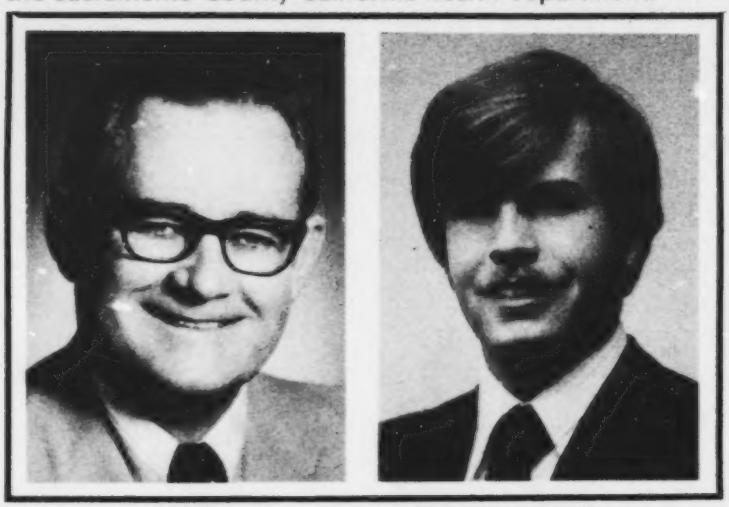
James Lake *Ralph Christensen*

Secondly, information has been disseminated utilizing both the news media of the Fort Wayne area (radio television, newspapers), and more direct personal communications including meetings, visits to individual landowners, and letters to individual landowners. As has been pointed out, the concept of the Black Creek project grew from a public discussion of the Maumee River and its problems. Followup meetings were open to members of various agencies and groups, and actions taken by the Board of Supervisors in applying for the grant and in conducting it have been done openly. As a result, rumors, suspicions, and fears that might have developed were largely avoided.

The work reported in this document is the result of the efforts of all of those people who cooperated in planning, carrying out, and analyzing the Black Creek project. Key personnel are mentioned in the following discussion

Environmental Protection Agency

Primary liason with the U.S. Environmental Protection Agency has been maintained through Ralph G. Christensen, U.S. EPA Grants Officer and Section 108 Program Coordinator, Region 5, Chicago. Christensen, a graduate of Brigham Young University, is a former deputy director and laboratory director of the Grosse Ille, Mich EPA laboratory, a former Chief of Bacteriology for the Detroit River - Lake Erie and Lake Huron field office and a former staff microbiologist for the Sacramento County California health department.



Carl Wilson *Dan Dudley*

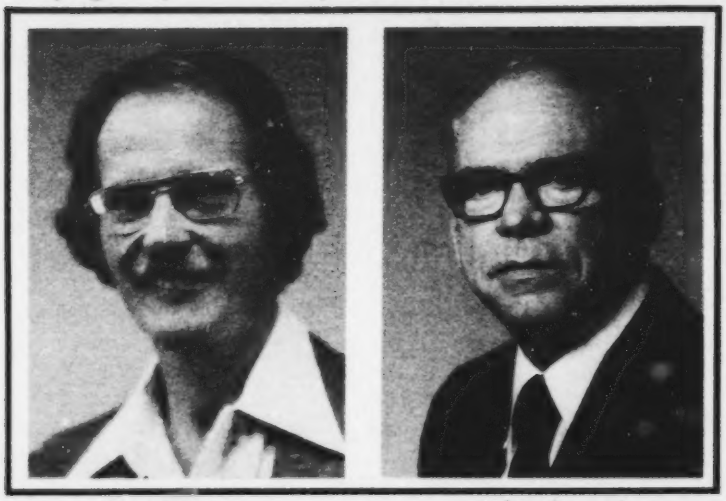
EPA project officer who has overseen the day-to-day operation of the project is Carl D.Wilson. Wilson has developed nonpoint source pollution projects in U.S. EPA Region V for the past six years. He has designed and implemented farming systems to utilize wastewater and sludge. He holds degrees in soil science and crop science from New Mexico State University. Prior to has association with U.S. EPA he was employed by the U.S. Department of the Interior, The Soil Conservation Service, and by private consulting engineering firms.

Allen County SWCD

Primary responsibility for the administration of the Black Creek project rests with the Allen County Soil and Water Conservation District. The district is administered by a Board of Supervisors, selected from Allen County and representing both urban and agricultural interests in soil conservation.

There have been a few changes in the composition of the board over the five-year history of the project. Current board members are Ellis McFadden, Roger Ehle, Mic Lomont, Eric Kuhne, and John Hilger. Ray Arnold and Gilbert Whitsel are past supervisors who were members of the board when the project was started. Don Rekeweg serves as an assistant supervisor. McFadden was chairman of the Board at the time the project was begun and retains administrative responsibility for the project. Ehle is currently board chairman.

The project director for Allen County is James Lake, executive secretary of the Allen County Board. Lake holds a BS in agricultural education from Purdue with a minor in soils. During the project he held responsibility for coordinating the activities of all groups involved in the project, kept budget records, and has had responsibility for carrying out policies set by the board.



Dan McCain *Richard Land*

Other employees of the Allen County District who have contributed to the project include John Pidlisny, a graduate civil engineer who served as a technician, Rex Journay, a graduate in agronomy who has worked primarily with tillage research, Allen Shope, a technician, and Dan Dudley, holder of a masters degree in aquatic biology employed by the District to assist in biological and microbiological studies.

Soil Conservation Service

Technical assistance was supplied on the project by the Soil Conservation Service of USDA. District Conservationist for SCS is Dan McCain. McCain has been responsible for SCS field office operations in Fort Wayne since 1969. He holds a BS in agronomy from Purdue. Substantial assistance to the project has been provided by John Denison, area technician

for SCS who is headquartered in Fort Wayne.

Numerous planners and technicians have been assigned by SCS to the project over its five-year history. These have included Greg Woods, Gary Carlile, Doene Goettl, Bill Howard, Stan Steury and Darrell Brown. On the area level, two area conservationists and an area engineer have been associated with Black Creek. The initial conservationist was Joe Branco. Ken Pyle assumed area responsibility during the final few years of the project. The area engineer has been C.F. Polland, who held that post throughout the five year project.

Two SCS state office workers, Leon Kimberlin, State Resource Conservationist for SCS and Eugene Pope, State Engineer, participated in the designed and initial execution of the project. Following reassignment of these personnel, Max Evans has served as State Engineer and Roy Hamilton as State Resource Conservationist.

Rolland Z. Wheaton *Jerry Mannering*

SCS assistance has also been provided by Bob Bollman, Assistance State Conservationist who also served on the report committee charged with preparation of final reports on the project.State Conservationists during the project have been Thomas Evans, Cletus Gillman and Buell M. Ferguson.

Purdue University

Purdue University has maintained a staff member in the field as well as an active research involvement at its Lafayette Campus. Richard E. Land has been the field coordinator of research at Fort Wayne with responsibility for continuing field data acquisition. The overall coordinator of research for Purdue has been Dr. Rolland Z. Wheaton. Wheaton has also conducted studies of ditch bank stability and of the

effectiveness of sediment basins. He holds a PhD from the University of California.

Work from the Purdue Agronomy Department has been divided into three major areas —simulated rainfall, soil and water chemistry, and tillage research. Primary responsibility for simulated rainfall was accomplished by Dr. Jerry V. Mannering, professor of agronomy and extension agronomist at Purdue where he has been a member of the agronomy department since 1967.

Soil and water chemistry has been the responsibility of Dr. Darrell Nelson, associate profesor of agronomy who has specilized in soil chemistry, biochemistry, and biological transformation of nitrogen in soils, and of Dr. Lee Sommers, Assistant Professor of Agronomy who is a specialist in microbiology, biochemistry and water chemistry. Dr. Nelson holds a PhD from Iowa State University and Dr. Sommers was granted a PhD from the University of Wisconsin.

Darrell Nelson *Lee Sommers*

Tillage research was begun by Harry Galloway, professor of agronomy and extension agronomist who until his retirment conducted research in soil drainage and tillage management. Following Galloway's involvement, tillage and demonstration plots became the responsibility of Don Griffith, research and extension agronomist at Purdue who has particular interest in corn and soybean cultural practices.

Modeling, simulation, automated data acquisition, and data handling have been conducted at Purdue by the Department of Agricultural Engineering. Principal researchers have been Dr. Wheaton, Dr. Edwin J. Monke and Dr. Larry F. Huggins. Dr. Monke is professor of agricultural engineering at Purdue where he teaches and does research

in soil and water resources. He holds a PhD in civil engineering from the University of Illinois. His principal research has been in the mechanics of erosion, hydrologic modelling, the hydraulics of sediment-laden flow, the treatment of water from small reservoirs for chemicals in soil. Dr. Huggins, also professor of agricultural engineering, has been involved with two aspects of the project: watershed modelling and field data acquisition automation. In the modelling area, he has been involved with supervising the development of the hydrologic components of the distributed parameter watershed model, ANSWERS. Two Purdue graduate instructors — David Beasley and Adelbert Bottcher -- have been involved with various aspects of the modelling effort. Beasley completed requirements for the PhD at Purdue in the spring of 1977 and currently holds the position of assistant professor of agricultural engineering at the University of Arkansas. Bottcher is continuing graduate study involved with the simulation of tile flow in an agricultural watershed.

Don Griffith *Edwin Monke*

Others involved in the agricultural engineering department have involved Dr. Jack Burney, visiting associate professor who specialized in increasing the capability and optimizing the storage and execution time requirements for the watershed model and Stephen J. Mahler, visiting instructor in agricultural engineering who has been primarily concerned with software in the systems involving the Black Creek Project.

Socio-economic studies at Purdue were begun by Dr. Ralph M. Brooks, assistant professor in the department of agricultural economics. When Brooks left Purdue, the work

was undertaken by Dr. William Miller, who has specialized in resource economics at Purdue. Miller holds the PhD from Michigan State University.

Others at Purdue associated with the project have included William P. McCafferty, an aquatic entomologist and Jerry L. Hamelink, an aquatic biologist. James B. Morrison, formerly an assistant to Rep. J. Edward Roush and currently an information specialist at Purdue has been involved with project documentation throughout the five year effort.

Administrative personnel at Purdue directly involved with the project have included Howard Diesslin, Director of the Indiana Cooperative Extension Service, Bernard J. Liska, Director of the Indiana Agricultural Experiment Station. Elsworth Christmas, Assistant Director of the Cooperative Extension Service and a member of the final report committee for the project, and the following academic department heads: Jerry Isaac, agricultural engineering; Marvin Phillips, Agronomy; Paul Farris, Agricultural Economics.

Larry Huggins *William Miller*

University of Illinois

The University of Illinois became involved with the transfer of James Karr from Purdue to that institution where he is associate professor of ecology. Karr has been involved with near stream vegetation effect on water quality, with microbiological sampling of Black Creek and with a study of fish in the Black Creek environment.

Other assistance

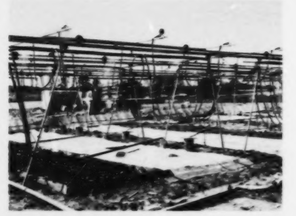
Additional assistance has been provided to the Black Creek project by Allen County Government and particularly by the

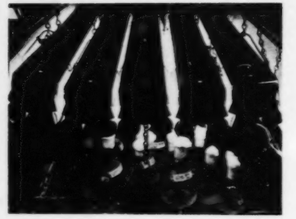
County Surveyor, William Sweet; County Highway Department Superintendent, William Jones; North Eastern Indiana Regional Coordinating Council Executive Director Elias Saomon; the Fort Wayne-Allen County Board of Health, Allen County Data Processing; Allen County Cooperative Extension Office, and Allen County Council and Commissioners.

James Karr

7

CONCLUSIONS





Conclusions reached by investigators on the Black Creek project are divided into two sets: those which essentially are drawn from formal research and those which are drawn as the result of experience in the project administration. These are presented here along with reference to section and subsection where they are supported in the report.

RESEARCH CONCLUSIONS

1. It is possible to conserve soil within the limits adequate for maintaining the soil resource, but nonetheless not meet proposed water quality standards.

Section 3 "Agricultural Pollution — What is It?"

2. Control of many agricultural pollutants is achieved by control of sediment. Nitrate nitrogen is an exception. Control of nitrate nitrogen can be achieved by the use of nitrification inhibitors, timing of the application of nitrogen fertilizers, and reduction of the amount of nitrogen applied as fertilizer.

Section 3 "Plant Nutrients"

3. Raindrop impact is of prime importance in the detachment of soil particles in the Black Creek Watershed.

Section 3 "Key to the Process — The Raindrop"

4. A relatively small percentage of the sediment entering the Maumee River and Lake Erie can be attributed to unstable ditch banks (less than 10 per cent).

Section 3 "Where Does It Come From?"

5. Erosion is dependent on storm intensity and amount. (a) Surface cover can reduce the erosion from any given storm. (b) The effectiveness of surface cover is dependent on its amount and quality. (c) For more intense storms, slope and slope length become more critical factors.

Section 3 "Where Does it Come From?"

6. Level of control of sediment and sediment related pollutants must be specified in terms of specific storm events. (a) Most sediment production in Black Creek Watershed was associated with a few intense storms. (b) Cost of control increases exponentially with design for more intense storms.

Section 3 "Flow During the Storm Event"

7. Total sediment contributions (loadings) of the Black Creek Watershed to the Maumee River, although typical of the Maumee Basin, are low for an agricultural watershed, ranging from about a quarter ton to slightly more than a ton per acre per year.

Section 3 "Sediment"

8. Septic tank effluent contributes to water quality problems in Black Creek. It accounts for a high percentage of soluble inorganic phosphorus and contributes to high fecal coliform counts. (a) Fecal coliform counts and fecal streptococci counts in Black Creek are high enough to interfere with swimmable and fishable water criteria. (b) Fecal coliform counts are generally higher in the Black Creek subbasin which includes effluent from the town of Harlan.

Section 1 "What Did We Learn?"

9. Disturbance of streams and ditches through reconstruction interferes with the breeding of several species of fish, primarily as a result of change of habitat structure.

Section 3 "Other Environmental Hazards"

10. Costs of achieving treatment of every acre of land to improve water quality would be extremely high. (a) It is possible to achieve water quality improvement by treating only critical areas. (b) These areas can be identified and a quantitative determination of their impact on water quality can be obtained by using the watershed simulation methods developed during this project. (c) Attempts to alter tillage by adopting uniform regulations covering relatively large areas would be more costly, would meet with greater farmer resistance, and would not be as effective as more selective programs.

Section 5 "What's it Going to Cost?"

11. Grab samples are not sufficient to give a true picture of sediment and related pollutant loadings.

Section 1 "What Did We Learn?"

ADMINISTRATIVE CONCLUSIONS

1. The Allen County Soil and Water Conservation District has demonstrated its ability to efficiently administer an extensive program of nonpoint source pollution control. The reliance on a local group for this administration is an important aspect of public acceptance and voluntary participation.

Section 1 "What Did We Learn?"

2. Best management practices have been subjectively selected by the District Board of Supervisors for the Black Creek area. These include field borders, grade stabilization structures, grassed waterways, livestock exclusion, pasture planting, sediment control basins, terraces, limited channel protection, and tillage methods which increase crop residue and surface roughness.

Section 4 "Best Management Practices"

3. Farm-by-farm Conservation Plans are useful in programs of water quality improvement. This type of plan should be simple in format and selective in approach. Obligations of participating farmers should be clearly delineated.

Section 4 "Putting the Practices Together — The Conservation Plan"

4. A voluntary program with sufficient incentive payments and technical assistance, can achieve significant land treatment aimed at improving water quality. Regulations or the threat of regulation may be required to achieve treatment on land owned by the relatively small number of probable non-cooperators.

Section 4 "Planning for Change in Black Creek Watershed"

5. Traditional cost sharing programs, based on a fixed percentage payment for every practice, are not adequate to sell best management practices for water quality improvement. While an overall average might be set, local districts should have the responsibility to set the rate on individual practices.

Section 4 "Land Treatment — A Part of the Management System"

6. Public information is critical to a successful land treatment

program. Landowners and the general public should be kept up to date on all phases of a program from conception through planning to implementation.